DOCUMENT RESUME

ED 256 884 CE 041 386

TITLE Developing Pre-Technical Secondary Education Programs: Rationale, Content, and Methodology.
INSTITUTION Georgia State Univ., Atlanta. Dept. of Vocational and Career Development.
SPONS AGENCY Georgia State Dept. of Education, Atlanta. Office of Vocational Education.
PUB DATE 84
NOTE 142p.; For other guides in this series, see CE 041 385-388.
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01/PC06 Plus Postage.
DESCRIPTORS Associate Degrees; Career Choice; Computer Oriented Programs; Cooperative Planning; Creativity; Curriculum Development; Decision Making; *Electromechanical Technology; *Electronics; Engineering Technicians; High Schools; Information Sources; Job Skills; Mechanical Design Technicians; *Mechanics (Physics); Models; Physics; Postsecondary Education; *Pretechnology Programs; Problem Solving; Program Descriptions; Program Implementation; School Business Relationship; Secondary Education; *Statewide Planning; Team Teaching; *Technical Education; Technological Advancement
IDENTIFIERS Georgia

ABSTRACT

This guide outlines the rationale, content, and methodology of a three-part high technology program that was developed in Georgia to provide secondary school students with training in the areas of electronics and electromechanical and mechanical technologies. Discussed first are the Georgia Initiative, the impact of high technology and the role of the engineering technician, Georgia's associate degree engineering technology curriculum, and the pretechnical curriculum model. The next section, which is an outline of the high school curriculum model, includes course descriptions, a list of competencies addressed in the individual courses, a list of affective skills, a discussion of the importance of applied problem solving and creativity in pre-technical curriculum, and examples of high school pre-technical curriculum tracks developed at one high school in Georgia. Provided in a section on implementing a pre-technical curriculum are guidelines pertaining to the following areas: obtaining information, developing a program description, obtaining input from business and industry, organizing a teaching team, problem solving in a high school environment, and obtaining needed equipment and materials. Appendixes to the guide contain a description of a course in unified technical concepts in physics and a career decision model. (MN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

GA8413303

ED256884

Developing Pre-Technical Secondary Education Programs: Rationale, Content, & Methodology

Prepared by

High Technology Curriculum Project
Vocational & Career Development Department
Georgia State University
Atlanta, GA

Harmon R. Fowler, Department Chairman,
Kenneth R. Allen & J. D. Fowler
Project Directors

Carolyn P. Ott - Curriculum Consultant
Data Processing Coordinator & Division Chairperson,
Walton Comprehensive High School
Marietta, GA

CE041386

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

a Mongtan

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Developed and Produced
Under Contractual Agreement with

Program Improvement and Evaluation
Office of Vocational Education
Georgia Department of Education
Atlanta, Georgia 30334
Charles McDaniel, State Superintendent of Schools
1985

high technology advisory council

1766 TWIN TOWERS EAST, CAPITAL SQUARE, ATLANTA, GEORGIA 30334, (404) 656-2547

March 14, 1985

JERRY BIRCHFIELD, CHAIR
ATDC

JAMES DIFFLEY, VICE-CHAIR
DELTA AIRLINES

ED BARNES, MEMBER
LOCKHEED - GEORGIA CO.

GEORGE BERRY, MEMBER
GEORGIA DEPARTMENT
INDUSTRY AND TRADE

JAMES H. BIGGERS, MEMBER
RELIANCE ELECTRIC CO.

EUGENE DEMONET, MEMBER
PRATT & WHITNEY

JIMMY HIERS, MEMBER
TDK ELECTRONIC CORP.

CLARENCE JETER, MEMBER
U.S. ARMY SIGNAL CORPS

SUSAN LILE, MEMBER
SCIENTIFIC ATLANTA

WANDA SAED
ROCKWELL INTERNATIONAL

BEN VANN
WARNER ROBBINS AIR LOGISTICS

RAY MORRISON, Ph.D.
HIGH TECHNOLOGY
COORDINATOR

M E M O R A N D U M

TO: The People of Georgia

FROM: R. E. Morrison, Jr., Ph.D.
High Technology Coordinator

RE: Preface to the Engineering Technology Curriculum

In the past two years, Georgia has taken the lead in human resource development of engineering technicians for the state's industry. This lead ensures that the industries locating in Georgia, or existing industries planning expansion or retooling will have a readily available supply of highly skilled, educated, and technically adaptable technicians. Over two million Georgians have been trained in the past twenty years in the state's network of thirty technical schools, junior and community colleges.

A quantum step was taken in 1982 when the General Assembly appropriated over $13 million to upgrade the technical school programs to "state-of-the-art" in the electronics, electromechanical and mechanical technologies. In that allocation were directives to develop two year engineering technology programs in the same three fields. These two year programs for a degree of Associate of Applied Technology were begun in September, 1982. The new curriculum, highly qualified technical staff, the latest in instructional equipment and a highly motivated student body are now in place. Our first graduating classes enter the "World of Work" in June 1984. The rhetoric of what should be done is behind us; high technology training for engineering technicians is a fact in Georgia.

New and expanding industries will find a new atmosphere of cooperation where the human resources required to ensure a skilled technician workforce is available. Productive and credentialed employees are available with a positive attitude toward change, adaptability, flexibility and upward mobility.

Each of the three high technology programs is based upon a solid foundation of mathematics, physics and an understanding of the fundamentals basic to the technologies. An understanding of systems, close ties to local business and industry, computer literacy, and characteristics of the high technology programs.

The Georgia "High Technology Advisory Council" was appointed by the Governor as a blue ribbon committee to advise the executive branch of government, the General Assembly, the Board of Education, the Board of Regents and the new Board on Post Secondary Vocational Education regarding high technology and engineering technology education issues. The council is composed of 12 high technology industry representatives in the state and is coordinated by the High Technology Coordinator.

Georgia's commitment to industry, "hi-tech" and quality training is now in place. Contained herein are the coordinated pieces that make up a comprehensive and viable program in the engineering technologies. It is in the basics - this is and will be the difference in Georgia's human resource development product.....the engineering technician.

Table of Contents

Section I. Introduction 1

Section II. The Georgia Initiative 15
An Overview of High Technology and the Engineering Technician 17

Georgia's Associate Degree Engineering Technology Curriculum 37

The Curriculum Model 49

Section III. High School Curriculum Model 51

Course Descriptions & Competencies 53

Affective Skills 75

Applied Problem Solving & Creativity 79

A Pre-Technical Curriculum 85

Section IV. Implementing a Pre-Technical Curriculum 89

Obtaining Information 93

Program Description 103

Obtaining Input from Business & Industry 105

The Teaching Team 111

Application/Problem Solving in a High School Environment 119

Equipment & Materials 123

Appendix A - UTC Physics Description 129

Appendix B - A Career Decision Model 139

Developing Pre-Technical High School Programs

I. Introduction

There appears to be no end in sight for the information revolution in American business and industry that we presently call high technology. The attention of the whole world continues to be focused on "high tech" and especially on the education and training requirements that it portends. The State of Georgia should be singularly proud that pilot programs it has initiated, attend to the major concerns that have been advanced by those who are familiar with the modern technological environment. Some indication of the kinds of concerns in education and training that are being expressed across the country are typified by the following:

- An Atlanta Journal-Constitution, September 11, 1983 article reported that research by Kenneth Hollander Associates reveals that top priority for high technology firms as well as most others in location or relocation of plants is a technically qualified workforce and an education climate that is progressive and research-oriented, and that our city does not rank very high in either area.
- The Commision on Excellence in Education Report entitled "A Nation at Risk," April, 1983 indicts the educational establishment for among other things, a tremendous weakness in technical preparation of American youth especially in math, science, and computer skills.
- A study by the Ohio State Center for Research in Vocational Education, co-sponsored by the American Association of commu-

nity and Junior colleges, the American Society for Training and Development, and the American Vocational Association, presented at the World Congress on the Human Aspects of Automation conducted by the Society of Manufacturing Engineers in August of 1983, reports data that indicates investment in human capital has far outstripped investments in technology in producing productivity gains in American industry.

- An insightful treatment of high tech issues entitled, Global Stakes: The Future of High Technology in America, by Dimancescu and Sitka (consultants based in Boston's Route 128 high tech district) the context of todays economy, it makes sense to invest more in education than in steel."
- Studies commissioned or conducted by such groups as Carnegie Mellon University (Robotics: Applications and Social Implications); the Upjohn Institute (Human Resource Implications of Robotics); and the U.S. Office of Technology Assessment (Automation and the Workplace: Selected Education and Training Issues); have emphasized that while education and employee training are critical to the diffusion and utilization of high tech automated devices, not nearly enough is known about how this technology will affect human beings at work to adequately plan programs.
- Research conducted by the Strategic Planning Department of the Georgia Power Company in 1982, concludes that in addition to an absence of leadership, the areas of education and workforce training were the primary inhibitors of expanded high technology growth and development in Atlanta.

William C. Missimer, Executive Vice President of Pratt-Whitney Aircraft, in a presentation entitled "Improving the Scientific and Technological Literacy of American Youth" before the Aerospace Education Foundation in Washington D.C. on September 15, 1983 said among other things:

"At least half of our high school graduates never had a single year of chemistry or physics. Beyond the 10th grade, only six percent of U.S. students take math. Average S.A.T. scores in math were down 17 percent in 1982 compared to 1972."

"A Northwestern University report issued in 1982 discusses the opportunities which could be available for youth who are pointed in the right direction; 112 corporations responding to a survey predicted an increase of 31 percent in their demand for technical graduates as soon as 1987. The critical areas indicated were in the electrical, mechanical, and computer science fields."

"A survey by the American Electronics Association underscores the need to fill more than 113,000 engineering and 140,000 para-professional engineering jobs, and those numbers don't take into account replacement for workers lost because of attrition."

"Involvement by industry in curriculum development is a must. No effort to help increase public awareness of the need for increased study of math and science would be complete without it."

It is particularly gratifying to realize that the State of Georgia has moved aggressively to plan, develop, and implement educational programs at the Post-secondary level which address every one of these very crucial issues. We have built in our State a human resource development system able to meet the challenges of the reorganization of work precipitated by implementation

of modern technology. This guidebook addresses areas which must now be pursued in our secondary schools so that we may continue our strong progress toward developing a technically competent population.

Pre-Technical Education

Although many states have moved to develop educational and training programs at the post-secondary level in technology, there has not been nearly the same level of effort applied at the secondary level. Technical education must become a priority for the high schools or there will never be the kind of broad educational competence among the general population that is needed to be successful in the increasingly complex technical work world.

High school students must be trained early in technical subjects, and they must be counseled throughout their educational experience in the attitudes and skills that will be needed in a world that is characterized by rapid change and "future shock." There must be a re-structuring of education around the demands of life in a technical environment if public education is to survive as we know it. An article by Stanley Pogrow in the Phi Delta Kappan, May 1982 which summarizes his study of education and technology issues for the National Institute for Education emphasizes the point, "If educators resist demands for technological relevance, U.S. education could become a victim of environmental collapse."

Fortunately the State of Georgia through the Office of Vocational Education has resources and data in hand that can structure a strong program of "pre-technical" education which can provide students with the skills required for a broad range of technically-oriented careers. It remains to implement these sorts of programs in selected high schools, test them through firm evaluation procedures and transfer this knowledge to as many schools across the state as possible. In order to plan and carry out such programs there are a number of things that we should know.

Some Startling Statistics

We must be aware that the rapid advance of high technology has caught American Education as much by surprise as did the Russian space bombshell of 25 years ago. The deficit we now have in education has not been so dramatically driven home as by Sputnik, but educators must take note of facts like these:

1. Japanese and German students take three times as much science and math as do American students. The average school year is 240 days; the average school day is 7 hours.

2. Only 6% of U.S. students take any physics at all. Only 50% take any math or science after grade 10.

3. Mathematics and science achievement scores have shown a steady decline through the 1970's. The mean SAT score in Math in the U.S. dropped from 502 in 1963 to 466 in 1980.

4. The population of the U.S. is twice as large as that of Japan, but the total number of engineering graduates in each country is 87,000 in Japan and 63,000 in the United States. The U.S.S.R. produces 300,000 engineering graduates each year.

5. When the country is undergoing near record levels of unemployment, the demand for computer-related technical workers is still three times the supply.

6. The demand for electronics engineers alone is expected to grow by more than 15% a year for the next 10 years. Approximately 1.5 technicians are needed per engineer and the demand for technicians is expected to grow at the rate of 17.5% annually.

An Operational Definition of High Technology

Whether in business, industry, government, or personal endeavor, high technology has come to mean the application of the most advanced and sophisticated ideas, devices, and processes available to the routine accomplishment of the tasks of work or of life. The most notable example of this is in the utilization of micro-sized digital electronic circuitry in the form of computers or other devices in almost every phase of human activity. High technology has been characterized by extremely rapid application of new research to practical situations. And an example, there are now available desk top computers suitable

and affordable for almost anyone in any office, which are as powerful as the large and expensive mainframes of just five years ago that required an entire staff to operate and maintain.

High Technology Job Roles

What kind of workers then do we in this country need to prepare? The bulk of careers in high technology industry (exclusive of management & support services) may be broadly categorized into four groups:

1. Engineers/Designers/Scientists

   The research and development phases of technical work are performed by members of this group. Their primary function is to conceptualize, design, and graphically or otherwise construct devices, processes, or systems which solve a technical problem or create a new product. Educational level varies from baccalaureate to Ph.D.

2. Technologists

   The technologist is often called a production, maintenance, or applications engineer. The most critical function of this group is to work with an engineering team to assure that the production process from design to finished product is efficiently implemented and maintained. Technologists generally have baccalaureate level training from a technical institute.

3. Technicians

   Technicians assist engineers, scientists and technologists, and usually work under their direct supervision. The technicians may be called upon to perform tasks which range from those of the traditional skilled craftsman or mechanic, up to light examples of design engineering. The technician's job would require at least the equivalent of an associate degree in the technical field.

4. Assemblers & Operators

   The assembler or operator's job role is exactly what the name implies. These individuals assemble products or devices or operate equipment of some kind. While the requirements in math and basic skills has increased for these workers, most industries hire high school graduates or less and provide whatever training is necessary for a specific set of tasks.

The first three categories: engineer/scientist, technologist, and technician, are usually of most concern to educational personnel and are the only ones we specifically address below. These three classifications should not necessarily be viewed as vertical in the sense of a career ladder. There is upward movement through roles, however, which is the result of experience, further education, or a combination of experience and education. It is often the case that after two individuals from different classifications have spent five or more years in the work force, the tasks they perform are very similar. This is usually dependent upon individual initiative, ability, and advancement. See Figure 1 for a graphic illustration of career succession and training for these job roles.

What High Tech Workers Do

A characteristic of the modern high technology environment is that teams of people from traditionally different disciplines have been integrated to work together in producing products. Designers, through the application of computer assisted design and manufacturing technology (CAD/CAM), now interface directly with production personnel, for example. In combination then, the high tech job classifications listed above (excluding the assembler/operator category) do the following:

1. They apply their knowledge of science and mathematics in research and experimentation.
2. They design and develop new products or processes. They also often design and develop modification for products or processes.
3. They plan and inspect the installation of complex equipment systems.
4. They often develop and implement programs of maintenance and repair of equipment systems.
5. They may be involved in planning the construction or production of various parts of devices or products. Often this production requires a complex arrangement of manpower, materials, and machines.

EDUCATION & TRAINING CONTINUUM FOR TECHNICAL CAREERS

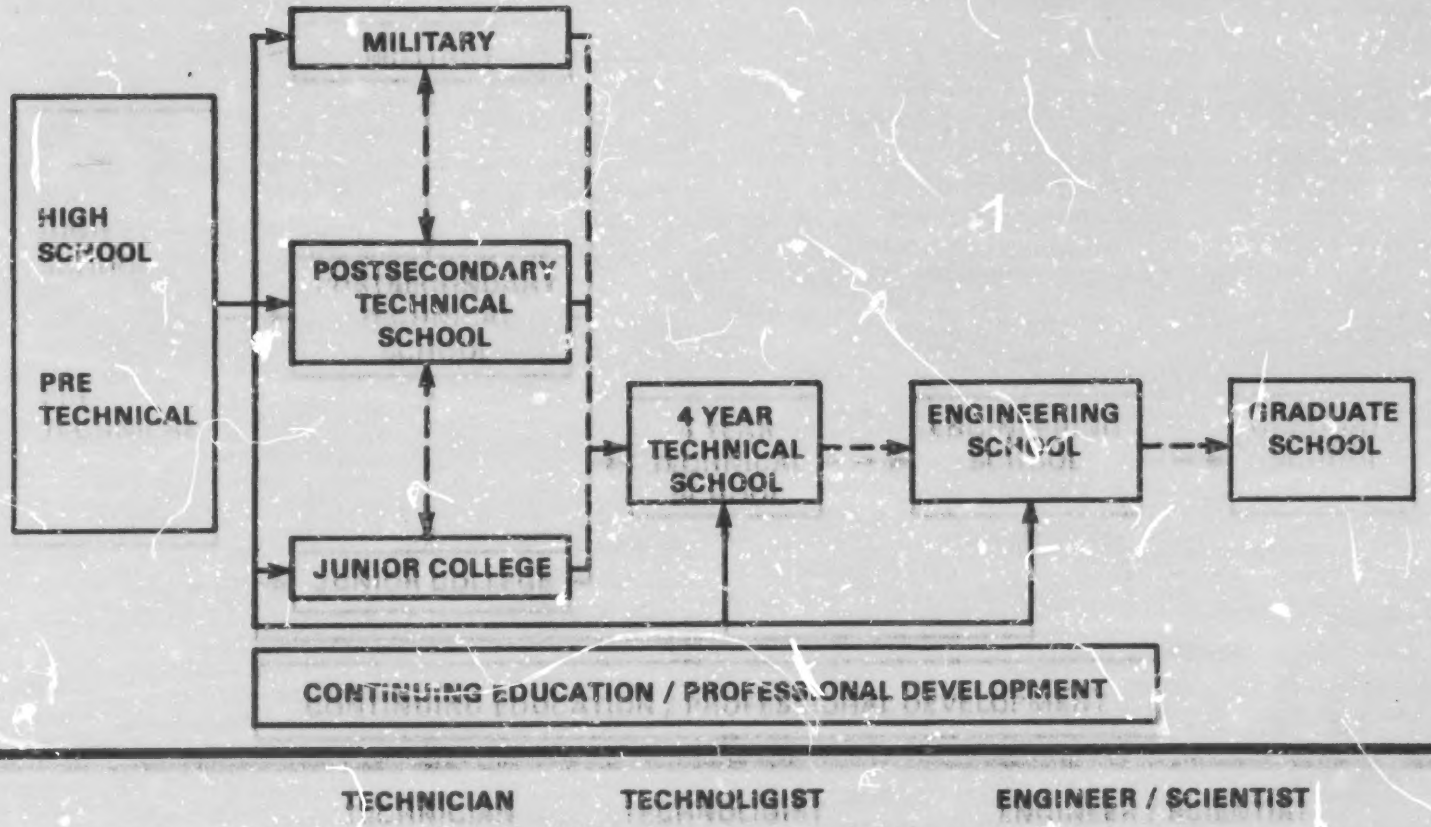

FIG. 1

6. They advise, plan, and estimate costs as a field representative of a manufacturing or distributor of technical equipment and/or products.

7. They are sometimes responsible for performance and environmental testing of mechanical, hydraulic, pneumatic, electrical components of equipment systems and for the preparation of technical reports covering the tests performed.

8. They prepare and interpret engineering drawings and sketches.

9. They select, compile, and use technical information from references such as engineering standards, handbooks, and technical digests.

10. They analyze and interpret information obtained from precision measuring and recording instruments and make evaluations upon which technical decisions are based.

11. They analyze and diagnose a variety of technical problems which involve many factors and variables. This sort of diagnosis reflects the broadest sense of the troubleshooting function and requires a knowledge of several interrelated technical fields.

Research with industry conducted at GSU and by the U.S. Department of Education has revealed that the following skills and abilities are needed to perform the activities listed above:

1. An ability to use mathematics as a tool. Algebra and trigonometry are essential to the development of ideas that make use of scientific and engineering principles. An understanding of higher mathematics such as analytical geometry and calculus is also necessary in understanding problems in design and research.

2. Proficiency in the application of physical science principles including the laws and concepts of physics and/or chemistry that are relevant to the chosen field of technology.

3. A thorough understanding of the materials and processes and devices commonly used in the technology including how to work with them or upon them to accomplish a job objective. This is especially true of the use and applications of digital computers.

4. An extensive knowledge of a specialized field within the broader field and the related sciences and engineering principles which distinguish it from other specializations. (Examples include computer technology as an electronics specialty, robotics in electromechanical, and machine design in mechanical technology.)

5. Communication skills that include the ability to interpret, analyze, and transmit facts and ideas graphically, orally, and in writing.

5. Problem solving ability which involves personal initiative and resourcefulness in dealing with new and changing situations.

7. The ability to adapt quickly and the willingness to learn rapidly when changes occur in the technology. Personal study and update are essential in the development of this ability.

8. The ability to work with many different kinds of people in a positive way. Work teams may include engineers, scientists, technicians, managers and supervisors, customers, production personnel, and maintenance personnel.

Education and Training for High Technology

The education and training path for persons who wish to be competent with high technology are fairly explicit. In the K-12 instructional program the track would be essentially the same for engineers, technicians, or technologists. It should include as much math and physical science as possible, especially physics. The laboratory experiences constructed for students should stress applications of math and science and be conducted by an inductive approach designed to foster problem solving ability. A "cookbook" kind of laboratory in which students simply follow a set of guidelines to accomplish a pre-specified outcome should be minimized or eliminated altogether. The surest way to dampen the enthusiasm of capable students is to deal only with abstract and theoretical concepts and never apply them to real world (or work) situations.

Wherever possible and as often as possible, technically destined students should work with a data processing system. Whether the systems are "micro" or "mini" makes very little practical difference since programming is similar enough to be transferable. Programming languages

are important from several standpoints and should be taught as a family of conversational methods with a computer, each having unique advantages and disadvantages. The three currently most useful languages for technical students are:

1. BASIC - The universal language of micro computers and many control devices. BASIC has the advantage of being easy to learn and widely applicable. If BASIC is learned thoroughly there is good transferability to higher level languages.

2. Fortran IV - The universal language of scientific applications. New languages now threaten its predominance.

3. PASCAL - Rapidly becoming a widely used language for multiple applications whether business or scientific. PASCAL is valuable because it teaches a highly structured and thoroughly documented approach to programming.

In addition to math, science, and computer courses, high tech students should take as much drafting and electronics as their schedules can permit and their schools provide. Electronics is the foundation for virtually all high technology, and some drafting/drawing skill is essential for technical design and problem solving. How much of each would be determined by the specific technical area and work role in which the student has an interest.

A high school education alone is not suitable for high tech careers. Students must pursue more in-depth training of some kind, either at a technical school or institute or at an engineering school. The military also still provides excellent technical training at almost any level of expertise imaginable. The availability of on-the-job or apprentice type training for high school graduates is virtually non-existent in high technology. The equivalent of a K-14 education is necessary at the entrance level for high tech occupations above the assembler/operator level.

II. The Georgia Initiative

The pretechnical program that we will present is intended to interface with Georgia Engineering Technology program initiated in six pilot Technical Schools in September of 1982. These programs are offered at the Dekalb, Augusta, Columbus, and Athens, Marietta, and Savannah Area Technical schools. The Associate Degree programs offer some level of transferability of credit to Colleges in this state and others. (The specific kind and amount of credit varies and should be investigated with the individual school.)

While the program outlined in this book is specifically applicable to the Associate Degree track it also may be easily articulated with preparation for any other technical role we have mentioned, as the course outlines and career tracks we present will indicate.

The following section is intended to give an overview of high technology with a specific discussion of the Associate Degree Engineering Technology program in Georgia. Any point that is made in this discussion applies as well to virtually any technical work role as it does to the Engineering Technician.

AN OVERVIEW OF HIGH TECHNOLOGY AND THE ENGINEERING TECHNICIAN

Introduction

The term "high technology" has been used in recent years to describe and refer to the most advanced devices, processes, and machinery in the modern world. The phrase carries with it a certain excitement; it conjures images of sophisticated and marvelous gadgets: computers, lasers, robots,

spacecraft, and the like. These and other fruits of the modern technological harvest, a "bonanza" crop by any definition, are the result of a great scientific awakening. They represent a fantastic leap of human understanding of physical and chemical events in nature and the application of that understanding to the problems of human life. All technological devices and processes - from the monkeywrench to the robot - are brought about by human creativity and skills applied to human needs and aspirations. Thus the excitement engendered by the term "high technology" is justified. Those who enter the sphere of high technology as participants, as technicians, find its complexity challenging and its boundaries ever-expanding.

Engineering Technology

Engineering technology in Georgia consists of three areas or specialties at the present time: electronic, mechanical, and electromechanical. All three of these strongly related areas are concerned with the application of energy to accomplish a desired task. Within each area, further specialties exist, such as robotics (use of electronically controlled machinery to perform mechanical actions), and laser electro-optics (the stimulated concentrated light beams that can perform tasks as diverse as metal cutting and eye surgery).

Electronic Technology

Electronic technology is a relatively recent means of controlling and using electrical phenomena (current and voltage). Electronics is concerned with very small currents flowing in a vacuum, in gases, or in solids (hence the term solid state).

Electronics is characterized by the extreme miniaturization of electrical systems (circuits) and components. Before electronics reached its present level of miniaturization, practical considerations of space and costs limited its applications. For example, miniaturization made it possible for spacecraft to carry - without the insurmountable problem of excess weight - the vast array of equipment needed to direct their operation. In the 1950s computer hardware that was necessary to accomplish complex calculations required a roomful of equipment and large amounts of current. In the 1980s, the same calculations can be accomplished by a hand-held unit running on current supplied by small batteries.

An important characteristic of electronic technology is that it has increased the speed by which information can be transmitted. In virtually all high-technology systems, information is transposed into electrical signals which can be processed much faster than was possible by conventional means. The prime example of this, again, is the digital computer, capable of carrying out in minutes, calculations that previously would have cost scientists and mathematicians years of work. Further on in this discussion, the efficiency and greater productivity brought forth by the computer will be examined in greater detail.

Mechanical Technology

Mechanical technology employs the principles of mechanical (Newtonian) or classical physics in the construction of machines and devices. In mechanical technology, hydraulic (fluid), pneumatic (gaseous), and thermal (heat) systems are used to exert force or do work. The mechanical actions that shape materials and join them together are the heart of technology.

While the basis of mechanical technology has been known for a very long time, the availability of synthetic materials and new metal alloys is pushing mechanical technology to new heights of sophistication. Equipment that was not previously producible is now possible using these new materials, with their special qualities such as light weight, resistance to heat and pressure, corrosive resistance, and so forth. Much of the production equipment that industry has relied upon for many years is now being redesigned by mechanical engineers so that it is more durable, more efficient, and more economical to operate.

One example of mechanical innovation is the new generation of rotary engines; in which the reciprocating pistons, crankshaft, valves, and so forth have been replaced by a smoothly rotating shaft with three lobes.

Electromechanical Technology

Electromechanical technology, as its name implies, is a new hybrid of electronic and mechanical technologies. Modern machinery and equipment are not isolated systems, but rather combine electronic control and mechanical action. Electromechanical systems are abundant today. Modern automobiles are a good example of an electromechanical system. The motive power of the automobile is produced in an internal combustion engine linked through a gear system to drive wheels, all mechanical functions. But the combustion process is measured and regulated by electronic devices.

The Role of the Engineering Technician

Engineering technicians, whether they be electronic, mechanical, or electromechanical engineers, are involved in the application of scientific and engineering principles in support of engineering activities. Tech-

nicians generally perform work on equipment; they construct, install, test, troubleshoot, and operate equipment and systems. Engineers, having taken on a more analytical, abstract role during the past several decades, tend now to be designers. Technicians provide a vital link in the process of research, development, and operation of modern equipment and devices because they are constantly involved with the physical reality of the moving parts, electrical circuits, and overall systems of technology.

Technicians work "hands-on" in many different capacities, depending upon their speciality area and the task at hand. They maintain and operate electronic equipment, high- and ultra-high-vacuum systems, spectroscopic instruments, and many other devices. They operate sophisticated scientific instruments or adjust sensitive instruments of process control. They troubleshoot and repair machinery used in production processes. Technicians may install or operate equipment such as the laser, aligning or adjusting as necessary. They calibrate (check, correct, or record the gradations) measuring instruments.

In an industrial setting, technicians sometimes oversee certain aspects of quality assurance and quality control. In such a role, they may measure performance parameters for a given product, using stress testing, X-rays, laser interferometry, and other processes to determine the product's strength and durability. They test materials for their resistance to heat, vibration, pressure, and chemicals. Technicians may provide important information to engineers and managers about problems that arise in production processes and materials.

In a research setting, technicians often assist in setting up experiments or test equipment, in gathering experimental data, and in record

keeping of experimental data. They build and install test equipment, troubleshoot experimental setups, and inform scientists and engineers about the behavior of equipment being used to gather information.

The development of new technologies requires a continuum of human resources that extends from the craftsperson to the engineer and scientist. Technicians must be more highly trained for a broader role than craftspeople traditionally have been, and they have a support role in relation to scientists and engineers. Technicians may work directly under the supervision of engineers or scientists, or they may function relatively independently day-to-day to execute the applications indicated by an engineer or scientist.

Broad-Based Training and Lifelong Learning

A very important aspect of the training of an engineering technician is that it should be broad-based and includes the fundamentals on which many specific systems are based. A person training to become an automobile mechanic would hardly wish to be trained only on the operation of the Datsun 280Z. While so doing, they might learn a number of things that apply to all cars, but their education would not mean nearly as much as if they had received a more general background in auto mechanics. The military demonstrated the difficulties associated with ignoring this principle when it began training radar technicians. When people were instructed in the specifics of one type of radar system, as old systems were modified or new ones introduced, they had to be completely retrained. These technicians were not informed about the underlying principles of the system they had learned in such a way that they could quickly adapt to a new system.

Training as an engineering technician must include the fundamentals on which the sophisticated tools of the modern world are based. It is essential for engineering technicians to know far more than what to do in a given situation; they must know the "why" of their actions. They must be problem-solvers, with multiple skills and knowledge that can be applied where and when needed.

The fundamentals of engineering technology include mathematics (algebra, geometry, introductory trigonometry), physics, electronics and mechanical devices and systems. A very important aspect of the technician's training is communications.

And the good surprise is that these subjects are only the beginning or, more correctly, the beginning of the beginning. The engineering technician who wants to remain on the "cutting edge" of new technologies must be committed to a lifetime of learning. Those who are content with their early training and do nothing to add to it throughout their early career are likely to find 10 years from now that many of their skills are obsolete. The breath-taking pace of change that we have been experiencing in the world for the last 30 years is going to accelerate. Already the time between a new discovery and its implementation in technology is decreasing. For example, electric motors were not put into general operation for more than 50 years after their discovery, while computers took half that long to grow from the first models into a vast industry. Integrated circuits began to be generally applied only three years after their invention. So we can expect changes of the same magnitude as the ones that have taken place in the last 15 years to have occurred again in the next five to seven years. Watch Out, Future Shock! Only the committed technician need apply.

Fortunately, companies and other employing institutions aid the willing technician in increasing his or her knowledge skills. Companies are most eager to train graduates of two-year technical programs who have already received a grounding in the basics of electronic and mechanical systems and, in so doing, have demonstrated a degree of commitment to a career. The technician learns much of the newest technology on the job, through the day-to-day experience of solving problems and working with knowledgeable people. Many companies have in-house specialty training courses or send employees to be trained by consulting educators or for university short courses in some specific aspects of their jobs.

This, then, is the kind of career on which technicians embark. Engineering technicians must make a commitment to an education in fundamental principles of technology and a subsequent lifetime of learning. The rewards of such an intense involvement include having a heady position in the frontier of human knowledge, gaining the deep sense of satisfaction that comes from increasing one's competencies, and maintaining a degree of job security unusual in our economically fluctuating world.

Technology and Productivity

To fully understand the impact of technological innovations on society and the role of an engineering technician, we need to examine the relationship between technology and productivity, and the economics of competition for world markets.

Productivity refers to the amount of materials or services produced in a given industry, as it relates to the labor, capital (money invested), natural resources, energy, and other factors that are put into the pro-

ducing system. At the risk of making a very complicated subject seem too simple, productivity can be described as the comparison of what comes out of a system of production to what is put into it. Productivity and the factors are generally agreed upon as critical in the productivity rates of modern industry:

- Improvement in production process - the introduction of better technology (requiring large amounts of capital).
- Existence of a trained workforce to implement and use technological advancements.
- Cooperation and motivation of individual employees.
- Effectiveness of management in organizing and delegating tasks, and in implementing technological changes.

While it is by no means the only factor that critically affects productivity, the clearest and strongest trend in recent decades has been that the introduction of better technology improves productivity. According to some economists, technological advance in the United States accounted for 90% of the increase in output per person-hour during the 20th century. One company recently calculated increased productivity at 900% after putting to work both robots and another new technological development known as EDM (electrical discharge machining).

The relationship of technological innovations to productivity is easiest to understand in relation to a specific manufacturing process. For example, traditionally, one machine tool is capable of performing one operation, such as drilling or milling, and the metal piece being worked is transferred by hand from one machine tool to the next. To be sure, this has been a great improvement, in terms of time and cost of production, over the lone blacksmith. However, the more advanced

machine tools of today take yet another leap forward. Multi-spindle machining centers are equipped with a set of tools that can carry out a series of operations, shaping an entire piece from raw metal to finish, under programmed instructions and without human intervention. This process known as Computer Numerical Control (CNC), increases productivity in a number of important ways:

- CNC tools can be run at far higher rates than conventional tools, for longer periods of time uninterrupted.
- CNC does not require individual training for persons to carry out each operation. Instead, many machines can be fed the same instruction tape (duplicated) that has been developed by one skilled programmer.
- Machines operated under CNC do not require the special jigs and fixtures required to hold the workpiece and guide the tools on conventional machines.
- CNC tools increase the time of machine operation by eliminating the time spent manually handing the tools from one machine to the other.
- Since they do not rely upon individual operators, machine tools are not subject to the human factors that slow production. They reduce time lost due to illness, injury, and fatigue; not the least of their advantages is that they eliminate the injuries to persons that are associated with certain machine operations.
- CNC tools often reduce the amount of scrap metal left after manufacturing.

In addition to achieving a much higher productivity rate, CNC improves the quality of materials produced. Pieces can be machined with greater accuracy, to closer tolerances, in greater complexity of

shape. Quality control is greatly facilitated under a system of uniformly programmed machines. All this should explain, in part, why the technician must be capable of working with great precision, using the closet tolerances measurable, with the highest degree of accuracy that can be achieved, with the most advanced instrumentation available. If you are constructing a machine that is going to be run at higher speeds, for longer periods, at higher temperatures, higher pressures, and higher flow rates - all to gain higher efficiency and productivity - you have to build it right.

Productivity of the U.S. and Other Nations

Traditionally, the U.S. has been the world leader in technological innovations. As a nation, the U.S. vastly outspends all others in research and development and exports more technology than all other nations. Until the last decade, the U.S. also led the world in implementing technological advancements; that is, in the taking of new ideas and putting them into practice. However, during the 1970s, the United States saw its technological leadership and related gains in productivity dwindle under competition from Japan and Europe, particularly West Germany. The U.S. remains a strong leader in terms of its manufacturing and service capabilities, but the traditional order of economic strengths and weaknesses among nations clearly is changing.

Most of the trade of the world occurs among industrialized nations. These nations strive to maintain a favorable balance of trade, or relationship of imports to exports of goods and services. In the past, industrialized countries have imported natural resources, or raw materials, from less-developed countries, and manufactured finished goods for their own consumption and for export. There is increasing demand in foreign countries for some element of manufacturing to be done locally. As less

developed nations (often called Third World nations) are beginning to implement new technologies, the old order, or status quo, of world trade is shifting. The Third World countries, along with the U.S., Japan, and Europe, are beginning to export the products of technology.

Presumably the goal of all nations is an economically healthy world. Extreme forms of protectionism (adding large tariffs to imported goods, such as Japanese cars or Brazilian steel) are likely to lead to a kind of economic warfare in which nobody wins. With the shifting balance of trade, the U.S. must define and emphasize its areas of greatest strength to meet the challenge of competing, and cooperating, in a world where technology and resources are shared.

The role of the engineering technician has a very direct relationship to the state of economic change now taking place. As mentioned, the primary strength of the U.S. has been, for many years, technological innovation and implementation. If we allow our capabilities in this area to stagnate, we must surely be prepared to accept a way of life quite different from the one we now enjoy. A key element in our continuing technological success, and especially in our using technology to solve modern problems, is a highly trained technical workforce, capable of fully supporting the engineers and scientists of the nation.

The Availability of Trained Technicians

The "lead time," or time required to train a technician, can be formidable. Companies often assume a portion of the training burden, but are eager to invest such training in persons who are already grounded in the fundamental principles of electronic and mechanical systems. Thus graduates of two-year postsecondary technical programs are prime candidates for such companies.

The availability of trained technicians is of considerable importance to companies that are planning to build or relocate. Companies are decidedly unenthusiastic about moving into a community where local citizens are for the most part employable only in entry-level, minimum wage jobs. The cost of importing technicians from out-of-state or, in some cases, from outside the country, may be prohibitive. Also, a firm generally seeks to establish itself as a cooperative element in the community, to blend smoothly into new surroundings. Importing all its high-level employees and hiring the local citizens in lower-level positions is not helpful in creating a cooperative atmosphere with the community.

The Impact of Technology on Society

The impact of technology on society is not a set of abstract ideas, existing mainly in science fiction novels or futuristic movies. You can and do observe every day the changes in human activities and alterations they make on the human environment. But the tendency of many people is to say simplistically, "ok, yeah, the computer and all that." To understand the scope and depth of what is happening in these last decades of the 20th century, we need to examine technological innovations more closely.

Information Processing

A good place to begin is in the area of information processing. With its huge memory and lighting-fast retrieval capacity, the computer (and all that) is the ideal instrument for storing and retrieving information as well as calculating problems too complex and lengthy to be handled by conventional means. The computer has assumed a great percentage of routine accounting and recordkeeping functions, freeing large numbers of people from the deadening pace of rote filing and calculation, and

accelerating routine transactions and interactions such as banking, payroll calculations, and stock inventory. Information so stored can be retrieved in moments and manipulated in a variety of ways. For example, with the aid of computers a company can monitor the sales of products continuously, thus determining when to increase or decrease production of items according to demand. Scientists and engineers can process huge arrays of information, incorporating many more variables than would be possible otherwise, thus arriving at more truthful conclusions, more accurate descriptions of natural events (such as chemical interactions on the molecular level), and far more useful designs for machines, bridges, buildings, automobiles, and airplanes. For example, engineers can describe the characteristics of a car in mathematical terms, feed them into a computer and determine the exact results of various types of automobile crashes without so much as turning the key in the ignition.

As a result of technological advances, more information is now more available to more people than ever before. Because of the vast storage and retrieval capacities of the computer, we can now walk into many major libraries, choose a topic, and in a matter of minutes, obtain a list of the most current information available on that subject, or a list of everything related to that subject that has been published for the last five years or ten years. Physicians can review medical case histories, lab reports, and the information given by cardiac monitoring machines, all within a half hour of a heart attack victim's admittance to the hospital. Now, more than ever before, information is literally "at our fingertips," when they are applied to the nearest computer terminal.

Production Processes

Production processes have been profoundly affected by recently developed technologies. The use of Computer Numerical Control in machining has already been discussed. In its sophisticated forms, automation involves robotics. Robots include elements that simulate aspects of human senses, muscles, and nerves. Electronic control systems include transducers (energy and converting sensory devices), programmed instructions for responding to the signals of transducers, and actuators (corresponding to muscles) that do the necessary work. Conveyors may transport parts between robots. Every unit of manufacturing can be coordinated, precisely timed for maximum speed of operation.

A simple example of how one segment of such maximum automation works is that of bottling beverages. Bottles moving on a conveyor cross a sensor (in the form of an inductive light probe) that detects the presence of the cap is absent or the bottle is empty, the capping mechanism will not be activated; instead another mechanism will take corrective action.

In a more sophisticated network of transducers, electronic controls, and actuators, entire automobile parts are machined and cast, and chemical processes convert raw materials into useful cleaning products, food products are packaged, labeled, and loaded for transport.

Perhaps the most revolutionary recent development in electromechanical devices is in the field of robotics. The productive capabilities of a factory "manned" by robots are staggering. In many cases, robots are taking over the most dangerous and difficult tasks of production. A G.E. plant recently began using robots in the precision forging of jet engine airfoils. Previously, forging operations had exposed operators to the uncomfortably high temperatures of a hearth furnace where metal

parts had to be loaded and unloaded. The same physically taxing motions had to be repeated continuously, and increased productivity placed a heavy burden on the operators' endurance. Robots carrying out the same operation produce 30% more parts per unit than do human operators.

As such production techniques are implemented, assembly line workers give way to technicians who build, maintain, and troubleshoot robots, CNC machine centers, automated materials-handling systems, and so forth. The unskilled employee gives way to the skilled employee, and routinized work gives way to more challenging and interesting jobs. Since these automated processes are multiple systems with electronic and mechanical elements such as electronic sensors, pneumatic drives, hydraulic control functions, and optical components, the technician who oversees their manufacture and operation must have multiple skills. A prime example is the copying machine that includes digital controls, a vacuum system for paper feed, and an optical component for photography. If the Xerox machine breaks down, it is hardly feasible for Xerox to send in a corps of technicians, each "wearing a different hat" of expertise. Enter the new "supertech" who wears many hats and possesses a range of expertise.

Some machines carry out processes that cannot be handled at all by human beings. In such areas, automation finds some of its most appropriate uses. In some chemical processes, particularly, reactions occur so fast that human beings are too slow in responding to control them. Instrument control can carry out these processes with no risk to persons.

Communications

In the area of communications, technology has turned the vast earth into, as the familiar phrase goes, "a global village." As nations and

individuals, we are aware of one another as never before. Satellite television brings events, as they occur, from across the earth into individual homes. Telemetry, which is the measurement of a physical quantity such as voltage, pressure, and temperature, and transmission of that quantity to a receiving apparatus that displays or records it, brought us pictures of Saturn by way of the Voyager spacecraft. Fiber optics promises to revolutionize communications by means of glass fibre strands (10 times smaller than a human hair in thickness) in which a modulated laser light beam can carry thousands of telephone conversations.

Word processors are radically changing the way that print media is produced, as everything from letters to books can be composed, edited, and stored without using a single sheet of paper. Even more important, the more repetitive aspects of typing and correction are greatly reduced, freeing typists to handle more written material.

Perhaps the favorite means of verbal communication in our society is the telephone, and it, too, has undergone technological improvements during the last few decades. "Call-waiting" now enables telephone users to receive notice of all incoming calls, even while the phone is in use. Telephone communication has so improved that transatlantic calls are now commonplace, accomplished with ease and clarity of connection.

Transportation

Transportation has been an area of dramatic change throughout the 20th century. Air travel has become an integral part of modern life. Businesses have decentralized with the knowledge that coherent management can be maintained through the availability of air travel. Commerce and manufacturing are aided by the transport of products, salespersons, executives, and consultants. With the advent of the supersonic transport, transatlantic flight has been reduced to a mere 2½ hours.

The technology of transportation has been strongly affected by the energy crisis. With increased fuel process, the nature of air and automobile technology has become the subject of change and debate. During the next decades, innovations in transport technology are certain to occur.

Changing Lifestyles

Technology has changed all but the essential species of humankind. Our lives are permeated by its effects, and we are only beginning to understand its implications and its possibilities. Most of us have a great deal more leisure time than did our grandparents. Few of us are compelled to grow or raise all of our food, or even part of it. Food preparation has been speeded by an array of kitchen wizardry, most recently, the microwave oven. Our means of travel - local to long distance - are convenient and quick; we scarcely have to consider distances that once consumed days or weeks to transverse. In the workplace we are aided by numerous devices that reduce our physical labor and the more rote aspects of mental exercise.

As technology has created leisure time, it has also supplied the means of using it. The technological "toys" of our time include television, radio, video tape recorder, stereo, and home computer, not to mention the steel tennis racquet, speedboat, carbon-filter golf club, and last but far from least, electronic video games.

Partly because of the new leisure, education has changed from the province of the young to a lifelong activity, enhanced by technological innovation the whole way along. Information is no longer issued largely from printed media; schoolchildren see videotapes, and use computers to aid their learning. While commuting to work, businessmen tune in to a

"short course" in management by way of cassette player. The most revolutionary change in education, however, stems from the fact that we have all become more aware of the wealth of information available. It is no longer easy to prescribe a given body of information that every schoolchild needs to know. There is so much to know, and more being discovered everyday, that few people feel certain of what is more crucial to learn.

This crisis in value brought about by technology is an understandable one. Society used to change so slowly that children knew what their lives would be like when they grew up, and parents knew how to prepare their children for adult life. Human beings, who cling to the familiar, the traditional, the tried-and-true, are now having to learn that the world is truly in constant motion. We have to learn to find meaning and forge out values in a changing world.

The challenge is very great. Many would turn their backs on it. They cite the environmental problems generated by new technologies, the displacement by automation of older workers who have obsolescent skills, and what they consider a generally unhealthy rate of change as reasons to turn back the clock or slow it down. Surely these problems must be taken into account - weighted heavily - as we choose when and where to apply new technologies. But to turn our backs on science and technology is seen by many as both impossible and irresponsible. As Jacob Bronowski, a philosopher of science, points out in his book Science and Human Values, "The world today is made, it is powered by science; and for any man to abdicate an interest in science is to walk with open eyes toward slavery."

Engineering technicians are examples of the kind of people who would meet the challenge of living a changing world.

GEORGIA'S ASSOCIATE DEGREE
ENGINEERING TECHNOLOGY CURRICULUM
ELECTROMECHANICAL
ELECTRONICS
MECHANICAL

The associate degree Engineering Technology programs in Georgia were developed over a two year period from 1982 to 1984. The curriculum that is outlined here is the result of the combined effort of experts from many high tech organizations working with teachers and curriculum development personnel to put together the most effective model of courses and activities for the education and training of modern technician. This program also articulates in both directions, with the high school program we are proposing in this document, and with baccalaureate programs of engineering technology. This kind of education is extremely valuable to many students as a first post-secondary step.

ELECTROMECHANICAL ENGINEERING TECHNOLOGY
STANDARD CURRICULUM - QUARTER SYSTEM
(SUGGESTED SEQUENCE)

First Quarter	Class	Lab	Contact Hour	Cr
D.C. Circuits	4	3	7	5
Computer Fundamentals	3	6	9	5
Algebra	5	0	5	5
Engineering Graphics	1	6	7	3
	13	15	28	18
Second Quarter				
Physics I	4	3	7	5
Trigonometry	5	0	5	5
A.C. Circuits	4	3	7	5
English & Composition	5	0	7	5
	18	6	26	20
Third Quarter				
Electronic Devices	4	3	7	5
Physics II	4	3	7	5
Analytic Geometry and Calculus	5	0	5	5
Circuit Analysis	4	3	7	5
	17	9	26	20
Fourth Quarter				
Technical Communications	4	3	7	5
Digital Electronics	3	3	7	5
Physics II	4	3	7	5
Elective Group I	4	3	7	5
	16	12	28	20
Fifth Quarter				
Electromechanical Devices	4	3	7	5
Elective Group II	4	3	7	5
Elective Group II	4	3	7	5
Digital Applications	4	3	7	5
	16	12	28	20
Sixth Quarter				
Programmable Controllers	4	3	7	5
Elective Group III	4	3	7	5
Elective Group III	4	3	7	5
Elective Group III	4	3	7	5
	16	12	28	20
Seventh Quarter				
Industrial Relations	5	0	5	5
Principles of Economics	5	0	5	5
Elective Group IV	4	3	7	5
EMT Problems (Elective)	0	9	9	3
	14	12	26	18

39

ELECTROMECHANICAL ELECTIVES

Group I - (Fourth Quarter)
Mechanical Devices & Systems
Fluid Power
Electrical Power & Distribution I

Group II - (Fifth Quarter)
Instrumentation & Controls
Fluid Power
Automatic Motor Controls I
System Drawing
Electrical Power & Distribution II
Feedback & Control Systems

Group III - (Sixth Quarter)
Micro-computer Applications I
Instrumentation & Controls
Thermodynamics
Feedback & Control Systems
Robotics I
Industrial Controls I
AC/DC Machines I
Automatic Motor Controls II

Group IV - (Seventh Quarter)
Industrial Electronics
Industrial Controls II
Programmable Controller Problems
Robotics II
AC/DC Machines II
Thermodynamics
EMT Problems
Plus, any of above not already taken

Group V - (Eighth Quarter) optional
Electronic Instrumentation
Control Systems Analysis
Heating & A/C Controls
EMT Problems

Note: Electives from MET or EET may be added to this list by consent of program coordinator.

It is recommended that EMT students have the following courses as a minimum.

Communications & Social Studies	20 hrs.
Mathematics & Science	30 hrs.
Computer & Graphics	8 hrs.
Technical Core	
D.C. Circuits	5 hrs.
A.C. Circuits	5 hrs.
Circuit Analysis	5 hrs.
Electronic Devices	5 hrs.
Digital Electronics	5 hrs.
Mechanical Devices & Systems	5 hrs.
Electromechanical Devices	5 hrs.
Digital Applications	5 hrs.
Instrumentation & Control	5 hrs.
Fluid Power	5 hrs.
Micro-computer Applications I	5 hrs.
Programmable Controller	5 hrs.
	118 hrs.
Electives (4 courses)	18 hrs.
	136 hrs.

ELECTRONICS ENGINEERING TECHNOLOGY
STANDARD CURRICULUM - QUARTER SYSTEM
(SUGGESTED SEQUENCE)

First Quarter	Class	Lab	Contact Hour	Cr
D.C. Circuits	4	3	7	5
Computer Fundamentals	3	6	9	5
Algebra	5	0	5	5
Engineering Graphics	1	6	7	3
	13	15	28	18
Second Quarter				
Physics I	4	3	7	5
Trigonometry	5	0	5	5
A.C. Circuits	4	3	7	5
English & Composition	5	0	7	5
	18	6	26	20
Third Quarter				
Electronic Devices	4	3	7	5
Physics II	4	3	9	5
Analytic Geometry and Calculus	5	0	5	5
Circuit Analysis	4	3	7	5
	17	9	28	20
Fourth Quarter				
Semiconductor Analysis	3	3	6	4
Digital Electronics	3	3	6	4
Physics II	4	3	9	5
Elective Group I	4	3	7	5
	14	12	29	18
Fifth Quarter				
Electromechanical Devices	4	3	7	5
Linear Integrated Circuits	4	3	7	5
Elective Group II	4	3	7	5
Digital Applications	4	3	7	5
	16	12	28	20
Sixth Quarter				
Control System Components	4	3	7	5
Technical Communications	5	0	5	5
Elective Group III	4	3	7	5
Elective Group III	4	3	7	5
	17	9	26	20
Seventh Quarter				
Industrial Relations	5	0	5	5
Principles of Economics	5	0	5	5
Elective Group IV	4	3	7	5
ELT Problems (Elective)	0	9	9	3
	14	12	26	18

ELECTRONICS ELECTIVES

Group I - (Fourth Quarter)
Communication Circuits
(Industrial Electronics may elect courses from Electromechanical or Mechanical sequence e.g. Mechanical Devices & Systems, Fluid Power, CAD I)

Group II - (Fifth Quarter)
Communications Circuits
Communication Systems
EMT or MET courses

Group III - (Sixth Quarter)
Micro-computer Applications I
Digital Communications
Satellite & Telecommunications
EMT or MET courses

Group IV - (Seventh Quarter)
Antennas Transmission lines and Microwaves
Micro-computer Applications II
Digital Communications
EMT or MET courses
ELT Problems

43

It is recommended that EET students have the following courses as a minimum.

Communications & Social Studies	20 hrs.
Mathematics & Science	30 hrs.
Computer & Graphics	8 hrs.
Technical Core	
D.C. Circuits	5 hrs.
A.C. Circuits	5 hrs.
Circuit Analysis	5 hrs.
Electronic Devices	5 hrs.
Semiconductor Analysis	5 hrs.
Digital Electronics	5 hrs.
Electromechanical Devices	5 hrs.
Communication Circuits	5 hrs.
Digital Applications	5 hrs.
Control Systems Components	5 hrs.
Micro-computer Applications I	5 hrs.
	54 hrs.
Electives	20 hrs.
	132 hrs.

MECHANICAL ENGINEERING TECHNOLOGY
STANDARD CURRICULUM - QUARTER SYSTEM
(SUGGESTED SEQUENCE)

First Quarter	Class	Lab	Contact Hour	Cr
D.C. Circuits	4	3	7	5
Computer Fundamentals	3	6	9	5
Algebra	5	0	5	5
Engineering Graphics I	1	6	7	3
	13	15	28	18
Second Quarter				
Physics I	4	3	7	5
Trigonometry	5	0	5	5
A.C. Circuits	4	3	7	5
English and Composition	5	0	5	5
	18	6	24	20
Third Quarter				
Physics II	4	3	7	5
Analytic Geometry and Calculus	5	0	5	5
Mechanical Devices & Systems	1	6	7	3
Elective (Group I)	1	6	7	3
	11	15	26	16
Fourth Quarter				
Statics	4	3	7	5
Physics III	4	3	7	5
Technical Communications	5	0	5	5
Elective (Group II)	1	6	7	3
	14	12	26	18
Fifth Quarter				
Electromechanical Devices	4	3	7	5
Elective (Group III)	3	4	7	5
Economics	5	0	5	5
Dynamics	4	3	7	5
	16	10	26	20
Sixth Quarter				
Elective (Group IV)	1	6	7	3
Strength of Materials	4	3	7	5
Computer Aided Manufacturing (CAM)	1	6	7	3
Machine Design	4	3	7	5
	10	18	28	16
Seventh Quarter				
Industrial Relations	5	0	5	5
Fluid Power	3	4	7	5
Elective (Any Group)	3	4	7	5
MET Problems (Elective)	0	9	9	3
	11	17	28	18

Electives - Mechanical Engineering Technology Program

Third Quarter (Group I)

* Engineering Graphics II

Computer Aided Drafting & Design (CAD) I

Fourth Quarter (Group II)

Computer Aided Drafting & Design (CAD) I

Manufacturing Process I

Fifth Quarter (Group III)

Engineering Materials

Manufacturing Process I

* Computer Aided Drafting & Design (CAD) II

Sixth Quarter (Group IV)

* Manufacturing Process II

* Computer Aided Drafting & Design (CAD) II

Seventh Quarter (Group V)

* Any of the above

* Require completion of I series

IT IS RECOMMENDED THAT A STUDENT INTERESTED IN DESIGN AS A CAREER OPTION HAVE AT LEAST THE FOLLOWING COURSES.

Communications and Social Studies	20 hrs.
Math and Science	30 hrs.
Computers and Graphics	17 hrs.
	67 hrs.
Technical Core	
A.C. Circuits	5 hrs.
Computer Aided Mfg. (CAM)	5 hrs.
D.C. Circuits	5 hrs.
Dynamics	5 hrs.
Electromechanical Devices	5 hrs.
Engineering Materials	5 hrs.
Fluid Power	5 hrs.
Machine Design	5 hrs.
Mechanical Devices and Systems	5 hrs.
Statics	5 hrs.
Strength of Materials	5 hrs.
	55 hrs.
Electives	6 hrs.
TOTAL	128 hrs.

47

IT IS RECOMMENDED THAT A STUDENT INTERESTED IN MANUFACTURING AS A CAREER OPTION HAVE AT LEAST THE FOLLOWING COURSES.

Communications and Social Studies	20 hrs.
Math and Science	30 hrs.
Computers and Graphics	11 hrs.
	61 hrs.
Technical Core	
A.C. Circuits	5 hrs.
Computer Aided Mfg. (CAM)	5 hrs.
D.C. Circuits	5 hrs.
Dynamics	5 hrs.
Electromechanical Devices	5 hrs.
Engineering Materials	5 hrs.
Fluid Power	5 hrs.
Machine Design	5 hrs.
Manufacturing Processes I	5 hrs.
Manufacturing Processes II	5 hrs.
Mechanical Devices and Systems	5 hrs.
Statics	5 hrs.
Strength of Materials	5 hrs.
	59 hrs.
Electives	8 hrs.
TOTAL	128 hrs.

III. The Curriculum Model

There are several basic areas of subject matter as we have mentioned above which are pre-technical curriculum should address. We will summarize these areas in some more detail and then give a description of the courses involved and the competencies that students should achieve as objectives for each course. It should be pointed out at this point that the competencies we list have been derived over several iterations of review and analysis by technical teachers and industrial advisory committees. The basic curriculum structure and expected outcomes of any technical curriculum should be routinely reviewed and revised as discussed in a later section of this publication on Business and Industrial Advisory Committees. The competencies presented for the curriculum areas in this section are from basic cognitive areas which form the foundations of the technological world and are consequently more immutable than are advanced technical subjects which deal with specific devices and systems.

The curriculum blocks are:

1. Basic Math (including algebra and trigonometry)
2. Applied Physics (taught with a systems orientation)
3. Communication Skills (basic grammar and composition)
4. Electronics/Electricity (DC & AC circuit fundamentals)
5. Graphics/Engineering (drawing and sketching)
6. Computer Fundamentals (operation and introductory programming)
7. A Survey Course in Engineering, Science, and Technology

We will also discuss two other areas:

- Affective skills important to technical work
- Applied problem solving ability and creativity in the technical world

Course Descriptions & Competencies Required

The following specific courses should form the basic pre-technical curriculum. The competencies listed are felt to be the optimum expected from students. These courses present the minimum subject areas that should be covered by a pre-technical student. Suggested lab topics are also listed.

ALGEBRA AND INTRODUCTION TO TRIGONOMETRY
(4 Semesters)

COURSE DESCRIPTION

GOAL: The goal of this course is to provide students with the basic skills and knowledge in Algebra and introductory trigonometry which will allow them to be able to solve technical problems. Topics include basic algebraic operations, functions and graphs, algebraic fractions, powers and roots, factoring, complex numbers, quadratic equations, trigonometric functions, and logarithms.

OBJECTIVE #1: Apply the vocabulary and basic operations of Algebra to:

1.1. Simplify mathematical and algebraic expressions.

1.2. Graph sets of numbers on the number line.

1.3. Add, subtract, multiply and divide algebraic expressions.

1.4. Apply exponents to real numbers and algebraic expressions.

1.5. Use significant figures and scientific notation to write large and small numbers.

OBJECTIVE #2: Apply the concepts of functions and graphing to:

2.1. Graph ordered pairs of numbers in the Cartesian coordinate system.

2.2. Graph linear equations in two variables.

2.3. Solve systems of two equations in two variables graphically.

2.4. Graph quadratic functions.

OBJECTIVE #3: Recognize and solve systems of linear equations by:

3.1. Algebraically solving systems of two or three equations in two or three variables.

3.2. Using determinants to solve systems of two or three equations.

OBJECTIVE #4: Apply the basic principles of operations with algebraic fractions to:

4.1. Write algebraic fractions in lowest terms.

4.2. Multiply, divide, add and subtract algebraic fractions.

4.3. Simplify algebraic fractions.

4.4. Solve fractional equations.

OBJECTIVE #5: Apply the laws of powers and roots to:

5.1. Identify roots of real numbers.

5.2. Evaluate algebraic radicals which represent rational numbers.

5.3. Estimate the value of radicals which represent irrational numbers.

5.4. Simplify expressions involving sums, products and quotients of radicals.

5.5. Identify and evaluate powers which have fractional exponents.

5.6. Solve radical equations.

OBJECTIVE #6: Use the methods of factoring to:

6.1. Find the greatest common factor.

6.2. Factor special polynomials (trinomial squares, difference of squares, sums or differences of cubes).

6.3. Factor general quadratic polynomials.

OBJECTIVE #7: Apply the concepts of complex numbers to:

7.1. Find the square roots of negative numbers.

7.2. Find sums, differences, products and quotients of complex numbers.

7.3. Use complex numbers in solving quadratic equations.

OBJECTIVE #8: Solve quadratic equations by:

8.1. Factoring.

8.2. Completing the square.

8.3. Using the quadratic formula.

8.4. Using the discriminant to determine the nature of the roots.

OBJECTIVE #9: Apply the basic properties of the trigonometric functions to:

9.1. Express angles in radian measure.

9.2. Solve right triangles.

9.3. Solve problems using vectors.

9.4. Graph the basic trigonometric functions ($y = \sin x$, $y = \cos x$, $y = \tan x$).

OBJECTIVE #10: Apply previously gained knowledge of graphing and exponential functions to:

10.1. Define logarithmic functions.

10.2. Learn the basic properties of logarithms.

10.3. Use tables to find logarithms.

10.4. Evaluate products, quotients and powers using logarithms.

These objectives may be met during the study of Algebra I, Geometry and Algebra II as they are taught in the general high school curriculum. More detailed study in the areas of the trigonometric functions, complex numbers in polar form, and logarithms, as taught in Advanced Algebra and Trigonometry, would provide the student a more complete foundation for the study of courses in engineering technology.

PHYSICS
(1 Semester)

COURSE DESCRIPTION

GOAL: The goal of this course is to provide students with knowledge of basic physical concepts as they apply across four energy systems which will allow them to analyze technical problems and explain the interaction of systems and components. Topics include review of vectors, graphs and traditional physics followed by a practical approach to the study of force-like quantities (forces), force transformers, displacement-like quantities (parameter), kinematics (parameter rate), resistive forces, magnetism, capacitance, inertance and energy converters. Students are shown how these concepts are applied to the four energy systems - mechanical, electrical, fluid, and thermal, and they will perform laboratory experiments that relate each concept to the four energy systems.

OBJECTIVE #1: Utilize basic concepts of traditional physics

1.1. Define vector and scalar, plot vectors, add and subtract vectors, and resolve vectors both graphically and algebraically.

1.2. Define and calculate the slope for linear and non-linear graphs.

1.3. Define and calculate from appropriate data the following physical concepts: displacement, velocity, acceleration, force, weight, pressure, density, mass, work and energy.

1.4. Explain and calculate energy and power.

1.5. Explain the nature of heat, describe the different temperature measurement systems and calculate amount of heat energy.

OBJECTIVE #2: Define the force like quantity in the different engineering systems

2.1. Calculate forces acting in mechanical translation.

2.2. Calculate torques acting in mechanical rotation.

2.3. Explain the operation of common pressure measuring devices such as manometers and bourdon tube gauges, and explain and calculate pressure in fluid systems.

2.4. Describe the different common temperature measurement devices and explain heat energy in terms of a temperature difference.

2.5. Explain the flow of current in terms of potential difference.

OBJECTIVE #3: Define the displacement-like quantities in the different engineering systems

3.1. Define and calculate work done in each engineering system in terms of force and displacement-like quantities.

OBJECTIVE #4: Explain the operations and make pertinent calculations appropriate for various types of force transformers.

4.1. Define and calculate TMA & AMA and calculate efficiency from TMA and AMA for simple machines such as levers, inclined planes, wheel and axel, and screw jack.

4.2. Explain simple machines as force, displacement or velocity multipliers.

4.3. Describe and make appropriate calculations pertaining to fluid and electrical force transformers.

OBJECTIVE #5: Define kinematics and solve typical kinematic problems

5.1. Explain concept of first and second time rates of change in the engineering systems.

5.2. Identify and define displacement, velocity, and acceleration and the analogous quantities in the other engineering systems.

5.3. Explain power as an energy rate of change.

OBJECTIVE #6: Identify and define concept of resistance

6.1. Identify and define resistance in each engineering system.

6.2. Relate resistance and loss of energy in a system.

6.3. Relate resistance to resistivity and conductance in each engineering system.

6.4. State criteria for and determine whether systems are connected in series or in parallel.

OBJECTIVE #7: Identify the parameters and perform appropriate calculations pertaining to the magnetic system

7.1. Define magnetic flux, magnetic fields, reluctance.

7.2. Compare magnetic and electronic circuits.

OBJECTIVE #8: Identify and define concept capacitance in each engineering system

8.1. Relate capacitance and the storage of potential energy.

OBJECTIVE #9: Identify and define inertia-like quantities in each engineering system except the thermal system

9.1. Relate inertia-like quantities and the storage of kinetic energy.

9.2. Define momentum and impulse in mechanical translation and related quantities such as angular and fluid momentum.

OBJECTIVE #10: Identify typical energy converters

10.1. Describe conversion of mechanical input energy, fluid input energy, electrical input energy, thermal input energy, and optical (light) input energy to other types of energy.

A.C. THEORY
(1 Semester)

COURSE DESCRIPTION

GOAL: To teach students the basic principles of A.C. theory so that they will be able to solve A.C. circuit problems involving capacitors, inductors, resistors, transformers, and magnetism and correlate A.C. circuit theory with laboratory experimentation.

OBJECTIVE #1: The student should be able to state and explain basic concepts and perform education related to magnetism and electricity, and electromotive force.

1.1. To explain what is meant by magnetic flux, flux density, flux intensity, magnetomotive force, permeability, reluctance, and retentivity.

1.2. To state the characteristics of magnetic lines of force.

1.3. To state the relationship between electricity and magnetism.

1.4. To state the left hand and/or right hand rule for determining direction of magnetic lines of force.

1.5. To define an electromagnet, calculate magnetomotive force, and explain residual magnetism.

STUDENT LABORATORIES:

1. Determine north and south pole of a permanent magnet.

2. Construct and test an electromagnet.

OBJECTIVE #2: The student should be able to explain basic concepts of A.C. current/voltage and resistance and utilize the oscilloscope to measure characteristics of the sine wave.

2.1. To explain the difference between direct current and alternating current.

2.2. To explain how a sine wave is generated.

2.3. To describe an A.C. voltage/current in terms of peak voltage/current, wave shape and frequency.

2.4. To determine peak, peak-to-peak, average, effective (RMS) and instantaneous values of a sine wave.

2.5. To explain the difference between frequency and period of a sine wave.

2.6. To find frequency if given time and time if given frequency.

2.7. To use an oscilloscope to measure amplitude and period of a sine wave.

STUDENT LABORATORIES:

1. Measure the peak-to-peak value and period of a sine wave.

OBJECTIVE #3: The student should be able to define, explain, and measure basic circuit value in RC, RL, and RLC circuits.

3.1. To solve problems involving vector algebra.

3.2. To define capacitive reactance.

3.3. To state the factors governing capacitive reactance and solve for capacitive reactance.

3.4. To use the operator J to write the equation for impedance of an RC circuit and solve for the impedance of a series RC circuit.

3.5. To define inductive reactance.

3.6. To state the factors governing inductive reactance and solve for inductive reactance.

3.7. To use the operator J to write the equation for impedance of an RL circuit and solve for the impedance of a series RL circuit.

3.8. To determine impedance of a series RLC circuit.

3.9. To determine admittance and impedance of a parallel RC, RL, and RLC circuit.

3.10. Define and determine resonant frequency.

STUDENT LABORATORIES:

1. Examine the effect of changing frequency on capacitive reactance.

2. Examine the effect of changing frequency on inductive reactance.

3. Determine the value of an unknown capacitor and/or inductor.

4. Verify A.C. theory in a series/parallel RC circuit.

5. Verify A.C. theory in a series/parallel RL circuit.

6. Verify A.C. theory in a series/parallel RLC circuit.

7. Find resonant frequency of a series/parallel RLC circuit.

OBJECTIVE #4: Use basic theorems to analyze A.C. circuits.

4.1. To use Thevenin's theorem to analyze A.C. circuits.

4.2. To use loop equations to analyze multi-loop A.C. circuits containing more than one power source.

4.3. To use Norton's theorem to analyze A.C. circuits.

STUDENT LABORATORIES:

1. Verify Thevenin's theorem.

2. Verify loop equation theory.

3. Verify Norton's theorem.

OBJECTIVE #5: Utilize and explain the operating characteristics of simple transformers.

5.1. To define transformer and transformer action.

5.2. To work problems involving transformer turns ratio.

5.3. To calculate power in secondary winding, percent efficiency, and power in primary winding.

5.4. To determine proper size fuse to use to protect a transformer from damage.

5.5. To state types of loses in transformer.

STUDENT LABORATORIES:

1. Step-up, step-down, and one-to-one ratio transformers.

2. Center taped and multiple windings in secondary.

D.C. CIRCUITS
(1 Semester)

COURSE DESCRIPTION

GOAL: To teach students the basic principles of D.C. circuit theory so that they will be able to solve problems involving current, voltage, resistance, capacitors, and time constants and to verify D.C. theory with laboratory experimentation.

OBJECTIVE #1: The student should be able to: define D.C., atomic number and parts of the atom, draw a simple circuit and indicate direction of current flow, state basic electrical units of measurement, express numbers in powers of tens and convert from a root unit in OHMS, VOLTS, AMPERES and WATTS to a prefix unit, and determine values of resistors using standardized color codes.

1.1. To define D.C., molecule, atom, atomic number, electron, proton, neutron, and ion

1.2. To draw a schematic diagram of a simple circuit and indicate the direction of current flow.

1.3. To state the units of measurement for EMF, current resistance, and power.

1.4. To express numbers in powers of tens and convert from a root unit in OHMS, VOLTS, AMPERES, and WATTS to a prefix unit.

1.5. To determine the OHMIC and tolerance values of resistors using the electronic industries association (EIA) standardized color code.

STUDENT LABORATORIES:

1. Use an analog VOM to measure the OHMIC value of resistors and correlate the measured value with the EIA color code.

OBJECTIVE #2: The student will be able to: state the three forms of OHM's law, state the interrelationship of basic electrical units, calculate voltage, current, resistance, and power in a simple circuit and plot the current vs. voltage graph.

2.1. To state the three forms of OHM's law.

2.2. To state the interrelationship of basic electrical units.

2.3. To calculate voltage, current, resistance, and power in a simple circuit.

2.4. To plot the current vs. voltage graph.

STUDENT LABORATORIES

1. Use a digital and/or analog VOM to measure voltage, current, and resistance in a simple D.C. circuit.

OBJECTIVE #3: The student will be able to: analyze a series circuit, solve problems involving the voltage division principle, analyze a parallel circuit, solve problems involving the current division principle, define and calculate conductance in parallel D.C. circuits and work problems involving meter loading.

3.1. To state the characteristics of a series circuit.

3.2. To analyze a series circuit in terms of total resistance, voltage drops, current, and power dissipation.

3.3. To state the voltage division principle.

3.4. To solve problems involving the voltage division principle.

3.5. To state the characteristics of a parallel circuit.

3.6. To analyze a parallel circuit in terms of total equivalent resistance, voltage, current and power dissipation.

3.7. To state the current division principle.

3.8. To solve problems involving the current division principle.

3.9. To define and calculate conductance in parallel D.C. circuits.

3.10. To explain meter loading and work problems involving meter loading.

STUDENT LABORATORIES

1. Use a digital and/or analog VOM to measure voltage, current, and resistance in a series circuit.

2. Use a digital and/or analog VOM to measure voltage, current, and resistance in a parallel circuit.

3. Use a analog VOM to determine meter loading.

OBJECTIVE #4: The student will be able to: find equivalent resistance for series-parallel circuits, convert to equivalent series and/or parallel circuits and analyze series-parallel circuits.

4.1. To convert a series-parallel circuit into an equivalent series and/or parallel circuit.

4.2. To find the equivalent resistance for a series-parallel circuit.

4.3. To analyze series-parallel circuits and determine individual currents, voltages, and power dissipations.

STUDENT LABORATORIES:

1. Use digital and/or analog VOM to measure D.C. voltages and currents in a series-parallel circuit.

OBJECTIVE #5: The student should be able to: use Thevenin's theorem to analyze D.C. circuits, use loop equations to analyze multi-loop, D.C. circuits containing one or more power sources, use Norton's theorem to analyze D.C. circuits, and convert interchangeably between Norton's and Thevenin's equivalent circuits.

5.1. To state Thevenin's theorem.

5.2. Use Thevenin's theorem to analyze D.C. circuits.

5.3. To use loop equations to analyze multi-loop D.C. circuits containing one or more power sources.

5.4. To state Norton's theorem.

5.5. To use Norton's theorem to analyze D.C. circuits.

5.6. To change from a Thevenin's equivalent circuit to a Norton's equivalent circuit and from a Norton's equivalent circuit to a Thevenin's equivalent circuit.

STUDENT LABORATORIES:

1. Verify Thevenin's theorem.

2. Verify loop equation theory.

3. Verify Norton's theorem.

OBJECTIVE #6: The student should be able to: calculate the total capacitance of capacitors in series of parallel, calculate the RC time constant, write the charging and discharging formulas and plot the charging and discharging curves for an RC circuit and describe troubles in capacitors.

6.1. To define capacitance and give the unit of measurement.

6.2. To state the three factors that determine capacitance.

6.3. To calculate the total capacitance of capacitors connected in series.

6.4. To calculate the total capacitance of capacitors connected in parallel.

6.5. To calculate the RC time constant.

6.6. To write the charging and discharging formulas for an RC circuit.

6.7. To plot the charging and discharging response curves for an RC circuit.

6.8. To describe troubles in capacitors.

STUDENT LABORATORIES:

1. Determine capacitance values by use of charging formula.

2. Determine capacitance values by use of discharging formula.

3. Checking capacitors with a VOM.

ENGLISH AND COMPOSITION
(2 Semesters)

COURSE DESCRIPTION

GOAL: This subject area is intended to enhance the student's skill in writing, grammar usage and composition. Topics for student exercises may be chosen from material discussed or experienced in technical courses. Course material will serve to integrate basic communication skills with studies in technical subject areas. Topics to be covered include grammar, writing skills and composition.

OBJECTIVE #1: The student will be able to develop basic skills and attitudes necessary for using good grammar and composition in the technical environment.

1.1. Explain the ways spoken and written composition are used in the technical environment.

1.2. Explain the need for effective written communication and an appreciation of the writing process.

1.3. Use effective technique for taking notes, following instructions, and taking tests as presented by the instructor.

OBJECTIVE #2: The student will be able to read and interpret expository essays and analyses.

2.1. Analyze ideas in an essay related to technology and society.

2.2. Articulate multiple points of view.

OBJECTIVE #3: The student should be able to utilize accepted rules of grammar and composition.

3.1. Use commonly misued words correctly in basic sentences.

3.2. Punctuate, capitalize, and spell correctly in this composition.

3.3. Recognize and write simple, complex, compound, and compound-complex sentences.

OBJECTIVE #4: The student should be able to write papers, essays, or themes using appropriate compositional methods.

4.1. Rewrite ambiguous statements into clear, terse sentences.

4.2. Recognize and write paragraphs using varied organizational techniques (cause & effect, descriptive, definition, etc.)

4.3. Use transitional words and paragraphs to achieve coherence and unity in writing.

4.4. Organize thoughts during the pre-writing stage using a written outline.

4.5. Effectively write a unified, well developed five paragraph theme following standard English grammar usage.

ENGINEERING GRAPHICS
(1 Semester)

COURSE DESCRIPTION

GOAL: The goal of this course is to provide technical students with an introduction to basic skills and techniques to communicate information graphically. Topics include graphic drafting technique and procedures; introduction to freehand sketching; schematic drawings; descriptive geometry; introduction to computer graphics.

OBJECTIVE #1: Discuss the importance of graphics as a universal communication made in the technological world.

OBJECTIVE #2: The student will be able to produce basic drawings using proper graphic drafting techniques.

2.1. Use drafting instruments to make simple lines and lettering.

2.2. Draw and interpret objects in orthographic projection.

2.3. Make simple freehand sketches that will describe an object or process in three dimension.

2.4. Draw and interpret objects in isometric.

STUDENT LABORATORIES

1. Experience and practice with above procedures.

OBJECTIVE #3: The student will be able to recognize and interpret basic schematic diagrams and symbols in a teacher selected technical field (electrical, fluid, mechanical, etc.)

3.1. Recognize basic symbols.

3.2. Read simple diagrams.

3.3. Draw simple diagrams.

STUDENT LABORATORIES

1. Experience and practice with the above procedures.

OBJECTIVE #4: The student will be able to apply selected topics in descriptive geometry to engineering graphics.

4.1. Give an overall explanation of the use of descriptive geometry in engineering graphics.

4.2. Graphically find the true length, slope and bearing of a line.

4.3. Determine true shapes on sizes of surfaces from alternative views utilizing the line and plan methods of descriptive geometry.

STUDENT LABORATORIES

1. Practice in the above procedures.

OBJECTIVE #5: The student will be able to explain the importance of computer aided graphics in modern engineering, science, and technology.

5.1. Define CAD/CAM.

5.2. List four applications of CAD.

5.3. Explain why CAD has become so widely used.

STUDENT LABORATORIES

1. Observe the production of a drawing on a CAD machine.

COMPUTER FUNDAMENTALS
(2 Semesters)

COURSE DESCRIPTION

GOAL: This subject area should provide students with the knowledge, skill, and attitude to begin the process of computer utilization as a tool in solving technical problems. Topics include orientation to computers, data entry techniques, flowcharting, fundamental programming concepts, use of computer hardware and programming in an interactive language.

OBJECTIVE #1: The student will be able to summarize the development of computer hardware which has led to modern computing devices

OBJECTIVE #2: The student will utilize proper data entry procedures

2.1. Identify the components of data entry equipment.

2.2. Use the terminal for direct data entry.

2.3. Develop entry skills including all alphanumeric characters, and other function characters.

OBJECTIVE #3: The student will be able to identify and describe components and functions of a digital computer system

3.1. Recognize the types of equipment found in modern computer centers.

3.2. Identify major parts of a computer and the function of each.

3.3. Explain the input/process/output basic processing cycle.

3.4. List the general characteristics of computer systems by size.

3.5. Explain the relationship between filing records and fields.

3.6. List the basic operations which may be performed by a computer system.

3.7. State how data is stored in main computer storage.

3.8. Illustrate how a computer system executes a program instruction.

3.9. State the different types of output which can be obtained from a computer system.

3.10. Use a computer related vocabulary.

OBJECTIVE #4: The student will be able to develop programs in an interactive language

4.1. Recognize four computer languages.

4.2. Use flowchart to develop computer programs.

4.3. Log-on and log-off successfully.

4.4. Develop computer programs in the BASIC language for a variety of applications to technical problems.

4.5. Utilize application packages which address a specific need.

4.6. State the difference in computers and interpreters.

4.7. Run list and edit a program.

4.8. Recognize and connect syntax and logic errors in a program.

4.9. Order events in a logical sequence and develop alogrithmic.

4.10. Interact with the computer via a computer terminal.

OBJECTIVE #5: The student will begin the use of advanced programming techniques

5.1. Use one and two dimensional arrays.

5.2. Use subroutines.

5.3. Use functions.

5.4. Use alphanumeric data manipulation.

5.5. Use sorting and searching operations.

5.6. Perform matrix operations.

5.7. Establish and manipulate data files.

ENGINEERING, SCIENCE, & TECHNOLOGY
(1 Semester)

COURSE DESCRIPTION

GOAL: Engineering, Science, & Technology is a survey course whose goal is to provide an overview of careers in technologically related careers as well as provide instruction in basic knowledges and skills that are required. This course may be offered to students wishing only to explore technical careers or as an introduction to a pre-technical educational choice.

A large portion of the course is devoted to the knowledge and skills used by those in science, engineering, and technology. These skills are particularly valuable to the student who has chosen the pre-technical educational option; however, the student taking the course only as career exploration will also find these skills highly applicable in their inventory of total life skills.

This career exploration aspect of this course will require several field trips to local industry as well as guest lecturers from the private sector. The instructor should also secure films (and/or tapes such as those that are available from the various professional engineering and scientific societies.

OBJECTIVE #1: The student will be able to give an in-depth description of scientific, engineering and technological careers.

1.1. List and explain the various areas of technology presented in class.

1.2. List five job titles in each area.

1.3. List some of the major effects of technological change on jobs.

1.4. Select a tentative personal career choice and explain or justify the choice.

OBJECTIVE #2: The student will be able to demonstrate selected basic skills and knowledges required in technological work roles.

2.1. Interpret mathematical formulas, particularly as applied to science, engineering and technology.

2.2. Perform dimensional analysis.

2.3. Recognize and use the International System of Units.

2.4. Describe and use the processes of precision measurement.

2.5. Interpret and prepare graphs.

2.6. Prepare a laboratory notebook.

2.7. Describe the basic processes of a system approach to solving technical problems.

Affective Skills

There are a number of affective skills which are important to technical workers that should be given a good deal of consideration while planning a curriculum. For the most part, affective skills cannot be learned as a separate subject area, as say, a unit on work attitudes taught in a specific discipline. This is not to say that such units should not be presented. It is simply that students will not "learn" this information at the most basic level, unless they have had experiences over a period of time which call on them to exercise these skills. Proper attitudes cannot be learned from a book or lesson without being utilized, any more than muscles can be developed by reading about body building. In both instances the structured use of attitudes or muscles, i.e. exercise, is what is necessary. This can only be accomplished in an educational setting which projects a career-oriented, professional, task-oriented learning environment. It is important whenever possible that the classroom be structured in a way that reflects the climate of the workplace. The vast majority of young people in the classrooms of this country are preparing for work at some point in their career, some immediately after high school, some after an intermediate training experience, and some after college and graduate school. No matter which path is chosen each learner will be better served if the school environment can become more closely a preliminary and preparatory exposure in concrete terms to what it means to pursue a career. Here then are some attitudes that should be developed by youngsters who wish to pursue a technical career:

- The ability to work alone as a self starter - Many, many job assignments in engineering and technical work will be individual projects either in-house or on visits to diverse work sites or customer

locations. The student must learn to budget time and be a self-starter, that is to be their own boss or motivator.

. Meet time lines - Time lines are critical and necessary facts of life in the technical world. Whether they are set by a manager, a contract, or the pressure of competitors or customers, they are characteristic of life in the fast lane of technology. Students must learn that time lines are often binary, gates, that is an excellent product or project produced late means nothing at all.

. Pace and mind set for problem solving - If you spend time with top technical talents at work on the specific content of their job, a somewhat obscure determinant of success can be observed. The nature of complex problem solving requires a deep intensity and urgency carried out in a calm and unhurried manner. The technical worker must be conscious of time, but not hurry. They must also be intense and involved without being frantic. There must possess a mind set analogous to top athelets who are said to play with "controlled aggression." The pressure of a situation must be channeled into a specific action and not toward worry or frustration. This is no easy attitude to master, but it allows for full brain functioning and in the case of an engineering or technician who must get a system back on line whose down time is measured in thousands of dollars per minute, an absolutely indispensable (and obviously valuable) attribute.

. The ability to work with groups - As we have said in the introduction, modern high tech organizations are more and more characterized by work groups comprised of traditionally separate and distinct organizational functions. Today such a work group might involve management, R&D, manufacturing, design, and quality control personnel from all levels

of the skill hierarchy in one group. CAD/CAM technology which integrates design and manufacturing through a common data base and communication network has done much to spawn such work organizations. More and more the technical worker will be called upon to work in diverse interpersonal situations. Educators have been told many times that today's business cannot use a person who is a non-communicator (if it ever could).

- A commitment to life long learning - Continuing education and professional development are the life blood of the technical employee. Computer systems double in speed and capacity every 18 months today. This is but one example of the speed with which the technical environment changes. The technical worker who wishes to be successful in any way, has no options. He or she must be committed to a lifetime learning process that may often have to be self-directed. There are many courses and publications available, and many professional societies listed elsewhere in this document, which sponsor continuing activities. The key is that students who aspire to technical competence must have the willingness to dedicate time to study and continuous education.
- The acceptance of, and a willingness to seek, change in the status quo - This attitude was recently given as a characteristic of the world's top business organizations in, <u>In Search of Excellence</u>. The high technolcgy world is at best, constantly in a state of "ordered chaos." There are many people who have difficulty with such a state of affairs. However, the individual who wants a routine, rubricized way of life will more than likely be miserable in a high tech environment. The high tech worker must, as we will discuss in the next section, be an experimenter

and a seeker of change. Such an individual must learn the basic rules of the game and then set about seeking new ways to define how the game is played. The term "movers and shakers" must have been coined especially for the high tech work world.

Applied Problem Solving and Creativity

This category of skill is so important in high tech occupations that it warrants a discussion separate from the well known cognitive, psychomotor, and affective areas. Actually this ability is an integration of knowledge with attitudes and skills. It calls for utilization of the very highest levels of cognition in the traditional hierarchies of learning (synthesis, and evaluation) and goes one step beyond into the realm of what might be called artistic endeavor. Perhaps the term high technology in itself is an attempt at an analogy with high art or high drama.

The utilization of more and more of the creative side of technical minds is a prime concern of high tech employers. Lester V. Ottinger, President of Robot Systems Incorporated first brought this to the authors' attention in an informal interview. Ottinger like most other high tech employers is interested in how employees are able to apply their knowledge to the creative solution of technical problems. Indeed most vendors of high tech systems such as computers and related equipment refer to their products as "total solutions." Very innovative companies such as Digital Equipment Corporation through their XCON "expert system" artificial intelligence program, are now even teaching computers to "think" in this creative way.

Creativity calls for a complex set of attributes called by Dr. Rosabeth Moss-Kanter of Yale University in her book "The Change Masters: Innovation for Productivity in the American Corporation; "kaleidascope thinking." A process by which creative workers and managers use experiences outside their field to bring shifts in thinking that create new patterns of ideas just as the slight shift of a kaleidascope makes new patterns of the fragments

it contains. It is at this point that attitude is important, there must be a willingness to depart from what is known or seen and explore what is not known or unseen.

The creative thinker in a technical environment then must be both structured and visionary. He or she must employ what is called "whole brain thinking." For years scientists have investigated the workings and interrelationships of the right and left hemispheres of the brain. Psychologists now believe with some certainty that the left hemisphere controls the verbal, logical, and analytical skill functions while the right hemisphere controls more intuitive, inspirational and creative thinking. Most people while functioning from both hemispheres in some situations, are either right brain or left brain dominant. One can quickly note that both right and left brain functions are important in technical problem solving. "Seeing" a creative solution to a problem, and then analytically constructing and testing that solution (making it play, so to speak) is at the very heart of what must be done to be successful in a high tech environment. A thorough treatment of this subject that is of considerable value to educators may be found in Whole Brain Thinking: Working from Both Sides of the Brain to Achieve Peak Job Performance, by Jacquelyn Wonder and Priscilla Donavan (New York: William Morrow & Co., 1984).

And amplification of what is needed for analytical problem solving skills and attitudes which is directly related to the whole brain concept can be found in the work of Anthony Gregorc on learning style An Adults Guide to Style; and Technical Manual: Research Background and the Gregorc Style Delineator, (Maynard, MA: Gabriel Systems, Inc., 1983).

Gregorc's research found four dominant learning styles that may be related to the brain dominance research discussed above. Gregorc feels that learners are dominated by either concrete or abstract thinking done in either a sequential or random fashion as follows:

1. Concrete sequential - This learning style uses the thinking channel that involves labeling, remembering, and controlling discrete parts. It is very methodical and step-by-step and highly structured as might be required in constructing, documenting, and debugging certain computer programs. It is highly left-brain dominated.
2. Abstract sequential - This learning style uses the channel that deals with abstract ideas, theories, and hypotheses. When well developed the channel allows the learner to visualize a total system or solution and develops a model or blueprint of how the solution may be reached. This shows a right-left brain interrelation with perhaps a slightly dominant right.
3. Abstract random - This channel is highly artistic, creative, sensory, and intuitive. It takes in the fully sensory input of the environment and offers an expression of it. It enables us to "see what everyone else has seen and think what no one else has thought." This channel is highly right brain dominated.
4. Concrete random - This channel predisposes the learner to be "scientific", to look into things to see what makes them work (concrete) but also to be inquisitive, question, and experiment (random). It is highly typical of the technical/scientific mind which creates new solutions from long research and experimentation. This channel shows left-right interrelationships with some left dominance.

These learning styles are important to educators as they bear heavily on the type of instruction that will be successful and imply that no one class can be taught in totally the same way if all are to progress. (See Gregorc and Butler "Learning is a Matter of Style", Voc Ed, April, 1984.)

From the standpoint of the kinds of minds and thought processes that must be developed for the technological workplace, this research has enormous implications. In the engineering, scientific, and technical environment it can be seen that, the technical worker who is successful above all others will utilize several styles as follows:

A. May get a sensory or intuitive impression "out of the blue," of a solution to a problem. A visionary right brain, Abstract Random thought process typical of many knowledge breakthroughs.

B. The idea must be subjected to an analytical thought process and alternate hypotheses and probabilities thoroughly considered and checked out before research and development can be realistically pursued (an idea for a product or design must often be laid out in a presentation and sold to management before they will allow R&D to begin.) This involves abstract sequential thinking and right-left interaction.

C. Whatever device or process is visualized must be constructed, evaluated, experimented with, tested over and over and explored in every way. Much serendipitous knowledge such as the discovery of x-rays, the development of light bulbs, etc. has been generated through the test and shake-out procedure. This is abstract sequential thinking, left-right orientation and the heart of the R&D experience.

D. Whatever is built or generated must be documented (as in computer programs) to be useful. Manuals and directions must be followed, step by step, research data must be pored over quantified and labeled, research reports must be written. This highly left brain, Concrete Sequential behavior.

Educators should note from this discussion, that while all styles of learners are needed in technical work roles, those individuals who are able to use all styles and consequently right and left brain simultaneously will be the most creative, the most analytical and therefore the most productive and valuable. This says quite a lot about the kind of educational experiences that should be provided. It says that such experience must be at the same time broad, and deep. As we shall point out later, it says much also about the integration of subject matter and the use of a practical problem solving approach to the teaching/learning process.

A Pre-Technical Curriculum

The instructional blocks and related competencies that are presented here are the result of research with industry conducted by the High Technology Curriculum Project at Georgia State University over a period of years from 1982 to the present date. The specific individuals and organizations surveyed in this research are noted in the acknowledgements section of this publication. Additionally, the State Department of Education has supported the organization of Curriculum Advisory Council for Engineering Technology which meets regularly to review and recommend curriculum in technical and pre-technical programs in the State's public secondary and post-secondary Vocational-Technical Schools and 2 year colleges.

On the following pages are examples of high school pre-technical curriculum tracks developed at Walton High School in Marietta, Georgia which has attempted to develop a pilot program based on the curriculum model presented in this publication.

We should perhaps make clear at this point that a pre-technical curriculum refers to a high school or other preparatory program of instruction, that prepares students to enter a post-secondary program at the associate degree or higher level in a technical, technological, or engineering related discipline.

SECONDARY SCHOOL TECHNOLOGY
SEMESTER SYSTEM
TECHNICIAN

1st Semester

Grammar/Composition I 92
Algebra I 92A
Int Electronics
Typewriting
General Science 92A
Int Drafting

2nd Semester

Int Literature 92
Algebra I 92B
Electronics IA (2 periods)
General Science 92B
Drafting IA (1 period)

3rd Semester

Grammar/Composition II 102
Geometry 92A
Biology 101A
World History 101A
Electronics IB (2 periods)

4th Semester

Lit Types 102
Geometry 92B
Biology 101B
World History 102A
Int Computer Programming
Drafting IA (1 period)

5th Semester

American Literature 112
Algebra II 102A
Descriptive Chemistry 112A
Becoming Physically Educated
U.S. History A
Special Computer Projects

6th Semester

Composition III 112
Algebra II 102B
Descriptive Chemistry 112B
Drafting IB (2 periods)
U.S. History B

7th Semester

Composition IV 122
Probability/Statistics
Physics A
Health
Drafting IIA (2 periods)

8th Semester

English Literature 122
Trigonometry
Physics B
American Government 122
Economic Studies
Drafting IIB (1 period)

Summary:
English - 4 units
Mathematics - 4 units
Science - 4 units
Social Studies - 3 units

Personal Development:
Health - ½ unit
Becoming Physically Educated - ½ unit
Typewriting - ½ unit

Pre-technology:
Computer Programming - 1 unit
Drafting - 4 units
Electronics - 2½ units

TOTAL 24

This Curriculum meets Georgia's Graduation Requirements now in effect through the 1987-88 school year.

SECONDARY SCHOOL TECHNOLOGY
SEMESTER SYSTEM
TECHNOLOGIST

1st Semester

Grammar/Composition I 92
Algebra I 91A
Physical Science 91A
Int Electronics
Typewriting
Foreign Language

2nd Semester

Int Literature 92
Algebra I 91B
Physical Science 91A
Electronics IA (2 periods)
Foreign Language

3rd Semester

Grammar/Composition II 102
Geometry 91A
Biology A
World History 101A
Electronics IB (2 periods)

4th Semester

Literature Types 102
Geometry 91B
Biology B
World History 101B
Electronics IIA (2 periods)

5th Semester

Composition III 112
Algebra II 101A
Chemistry IA
Becoming Physically Educated
U.S. History A
Int Computer Programming

6th Semester

American Literature 112
Algebra II 101B
Chemistry IB
Special Computer Projects
U.S. History B
Int Drafting

7th Semester

Composition IV 122
Analysis A (Pre-Calculus)
Physics A
Health
Special Computer Projects
Drafting IA (1 period)

8th Semester

English Literature 122
Analysis B (Pre-Calculus)
Physics B
American Government
Economic Studies
Drafting IB (1 period)

Summary:
English - 4 units
Mathematics - 4 units (through pre-calculus)
Science - 4 units
Social Studies - 3 units

Personal Development:
- Health - ½ unit
- Becoming Physically Educated - ½ unit
- Typewriting - ½ unit
- Foreign Language - 1 unit

Pre-technology:
- Computer Programming - 1½ units
- Drafting - 1½ units
- Electronics - 3½ units

TOTAL 24

This Curriculum meets Georgia's Graduation Requirements now in effect through the 1987-88 school year.

SECONDARY SCHOOL TECHNOLOGY
SEMESTER SYSTEM
ENGINEER/SCIENTIST

1st Semester

Grammar/Composition I 91
Geometry 91A
Physical Science 91A
Foreign Language
Typewriting
Int Electronics

2nd Semester

Int Literature 91
Geometry 91B
Physical Science 91A
Foreign Language
Electronics IA (2 periods)

3rd Semester

Grammar/Composition II 101
Algebra II 101A
Biological Frontiers 101A
World History 101A
Foreign Language
Int Drafting

4th Semester

American Literature 111
Algebra II 101B
Biological Frontiers 101B
World History 101B
Foreign Language
Drafting IA (1 period)

5th Semester

Composition III 111
Analysis A (Pre-Calculus)
Chemistry IA
U.S. History A or AP History
Becoming Physically Educated
Int Computer Programming

6th Semester

English Literature 121
Analysis B (Pre-Calculus)
Chemistry IB
U.S. History B or AP History
Health
Special Computer Projects

7th Semester

Composition IV 122 or AP English
Calculus A
Physics A
Chemistry IIA
American Government
Special Computer Projects

8th Semester

World Literature 121 or AP English B
Calculus B
Physics B
Chemistry IIB
Economic Studies
Advanced Drafting (1 period)

Summary:
English - 4 units
Mathematics - 4 units (through Calculus)
Science - 5 units
Social Studies - 3 units

Personal Development:
Health - ½ unit
Becoming Physically Educated - ½ unit
Typewriting - ½ unit

Pre-technology:
Computer Programming - 1½ units
Drafting - 1½ units
Electronics - 1½ units

TOTAL 24

This Curriculum meets Georgia's Graduation Requirements now in effect through the 1987-88 school year.

Implementing A Pre-Technical Curriculum

This section is intended to give some hints and information on program organization and program development. There are six sub-headings of importance:

1. Obtaining Information
2. Program Descriptions
3. Obtaining Input from Business and Industry
4. The Teaching Team: Integrating Technical and Academic Curricula
5. Application/Problem Solving in a High School Environment
6. Equipment and Materials

I. Obtaining Information

There are several categories of information sources that can be of help in planning a pre-technical curriculum. Looking at what has been done in other places can save a great deal of planning time and give the program a firm basis of validation from the beginning.

. State Education Agencies - Several states have begun technical and pre-technical programs in the last few years and months notable among these of course is our own State of Georgia effort under the direction of Dr. Raymond E. Morrison the High Technology Coordinator for the state, and the High Technology Curriculum Project at Georgia State University which is responsible for this publication.

Other states which have mounted significant efforts are: Florida, South Carolina, North Carolina, Tennessee, Illinois, Wisconsin, Michigan, and Ohio. Fortunately there is information source that can be typed which ties together State Department of Education and their various projects: The National Network for Curriculum Coordination in Vocational Technical Education. It has regional centers as follows.

[illegible]st Curriculum Coordination Center
[illegible]ational Ed. Resource Center
[illegible]s University
[illegible]d Matawan Road
Old Bridge, NJ 08857

Southeast Curriculum Coordination Center
Mississippi State University
Research and Curriculum Unit
Drawer DX
Mississippi State, MS 39762

East Central Curriculum Coordination Center
Illinois Vocational Curriculum Center
Sangamon State University, E-22
Springfield, IL 62708

Midwest Curriculum Coordination Center
State Department of Vocational and Technical Education
1515 West 6th Avenue
Stillwater, OK 74074

Northwestern Curriculum Coordination Center
Building 17, LS-10
Airdustrial Park Building
Olympia, WA 98504

Western Curriculum Coordination Center
College of Education, Wist Hall 216
University of Hawaii
1776 University Avenue
Honolulu, HI 96822

Representatives from the Southeast are given below. Please contact Patt Stonehouse (address below) with the Georgia Department of Education for Curriculum information in the State of Georgia.

Alabama . . . . . Jim Kendrick

Vocational Curriculum Development Unit
Division of Instructional Services
State Office Building, Room 802
Montgomery, AL 36130
(205) 261-5225

Florida . . . . . David McOuat

Vocational Division
State Department of Education
Knott Building
Tallahassee, FL 32301
(904) 488-1831

Georgia . . . . . Patt Stonehouse

Office of Vocational Education
Georgia Department of Education
Twin Towers East, 17th Floor
Atlanta, GA 30334
(404) 656-4059

Kentucky . . . . . John Horton

Curriculum Development Unit
Office of Vocational Education
2024 Capitol Plaza Tower
Frankfort, KY 40601
(502) 564-2890

Mississippi . . . . . Jimmy McCully

Research and Curriculum Unit
P.O. Drawer DX
Mississippi State University
Mississippi State, MI 39762
(601) 325-2510

North Carolina . . . . . Meg Murphy

Division of Vocational Education
North Carolina Department of Public Instruction
Room 550, Educational Building
Raleigh, NC 27611
(919) 733-7893

South Carolina . . . . . Robert T. Benson

Vocational Curriculum Development Section
1237 Gadsden Street
Columbia, SC 29201
(803) 758-5971

Tennessee . . . . . vacant

Curriculum & Professional Development
Division of Vocational-Technical Education
Tennessee Department of Education
205 Cordell Hull Building
Nashville, TN 37219
(615) 741-3446

Technical Societies and Organizations - One of the best sources of information, materials, and even grants and financial support are the various technical and engineering societies. These organizations sponsor literally thousands of projects each year in conjunction with educational institutions. Most also have A-V libraries which may be called upon. In Georgia, the Instrument Society of America, The Society of Manufacturing Engineers, The Georgia Society of Professional Engineers (404-355-0177), and the IEEE have sponsored important educational activities. A partial list of such organizations is provided below.

SOCIETIES AND ORGANIZATIONS

American Automatic Control Council (AACC)
P.O. Box 12277, Research Triangle Park, NC 27709 919/549-0600

Numerical Control Society (Automatic Control) (NCS)
519 Zenith Drive, Glenview, IL 60025 312/297-5010
Responsibility for the application of numerical control techniques.

Institute of Electrical and Electronics Engineers (IEEE)
345 East 47th Street, New York City, NY 10017 212/644-7910

International Society for Hybrid Microelectronics (ISHM)
P.O. Box 3255, Montgomery, AL 36109 205/272-3191
Ceramics, thick/thin films, semiconductor packaging, discrete semiconductor devices, and monolithic circuits. Bimonthly newsletter.

National Engineering Consortium (NEC) (Not an association)
1211 West 22nd Street, Oak Brook, IL 60521 312/325-5700
Provides fellowships, scholarships, grants, and endowments to engineering students for furthering electronic training.

Accreditation Board for Engineering and Technology (ABET)
345 East 47th Street, New York City, NY 10017 212/644-7685
Accredits college engineering curricula and engineering technology programs.

American Association of Engineering Societies (AAES)
345 East 47th Street, New York, NY 10017 212/686-5676
Advance the science and practice of engineering in the public interest.

American Institute of Industrial Engineers (AIIE)
25 Technology Park, Norcross, GA 30092 404/449-0460
Design, improvement, and installation of integrated systems of people, materials, equipment, and energy.

American Institute of Plant Engineers (AIPE)
3975 Erie Avenue, Cincinnati, OH 45208 513/561-6000
Newsletter 8 times/year; journal quarterly.

American Society for Certified Engineering Technicians (ASCET)
4450 West 109th Street, Overland Park, KS 66211 913/341-5669
Skilled technicians whose training and experience qualify them to provide technical support and assistance to registered professional engineers. Certified Engineering Technician, bimonthly.

Automated Procedures and Engineering Consultants (APEC)
Miami Valley Tower, Suite 2100, Dayton, OH 45402 513/228-2602
Application of up-to-date computer technology to building design. Journal, bimonthly.

Engineering Technologist Certification Institute (ETCI)
2029 K. Street, NW, Washington, DC 20006 202/659-5773
Not a membership organization. Issues certificates for Associate Technologists and Engineers.

Societies and Organizations (contd.)

American Institute for Design and Drafting (AIDD)
3119 Price Road, Bartlesville, OK 74003 918/333-1053
Design and Drafting News, monthly.

Design and Drafting Management Council (DDMC)
P.O. Box 11811, Santa Ana, CA 92711 714/838-5800
Computer-assisted drafting. Library. Commentary, monthly.

Engineering Reprographic Society (ERS)
P.O. Box 5805, St. Louis, MO 63134 314/232-7386

American Federation of Information Processing Societies (AFIPS)
1815 North Lynn Street, Suite 800, Arlington, VA 22209 703/558-3600
Serves as national voice for the computing field, advances knowledge of the information processing sciences.

Association for Computing Machinery (ACM)
1133 Avenue of Americas, New York City, NY 10036 212/265-6300

Computer and Automated Systems Association of the Society of Manufacturing Engineers (CASA/SME)
Box 930, One SME Drive, Dearborn, MI 48128 313/271-1500

Instrument Society of America (ISA)
P.O. Box 1227, Research Triangle Park, NC 27709 919/549-8411
Instruments and controls in science and industry. Instrumentation Technology, monthly.

Society of Manufacturing Engineers (SME)
P.O. Box 930, Dearborn, MI 48128 313/271-1500
Library. Manufacturing Engineering, monthly.

American Society for Mechanical Engineers (ASME)
345 East 47th Street, New York City, NY 10017 212/644-7722
Sponsor for ANSI. Library. Applied Mechanics Review, monthly. Mechanical Engineering, monthly.

American Institute of Physics (AIP)
335 East 45th Street, New York City, NY 10017 212/661-9404

American Physical Society
335 East 45th Street, New York City, NY 10017 212/682-7341

American Society for Quality Control (ASQC)
161 West Wisconsin Avenue, Milwaukee, WI 53227 414/272-8575
Quality Progress, monthly.

International Institute for Robotics (IIR)
Box 21078, Dallas, TX 75211
Small library. Robotics Newsletter, monthly.

Robot Institute of America (RIA)
P.O. Box 930, Dearborn, MI 48128 313/271-1500
Robotics Today, quarterly.

Societies and Organizations (contd.)

American Production & Inventory Control Society (APICS)
500 W. Annandale Road
Falls Church, VA 22046-4272 703/237-8344

Computer Aided Manufacturing-International Inc. (CAM-I)
611 Ryan Plaza Drive
Suite 1107
Arlington, TX 76011 817/365-5328

Electronics Industries Association (EIA)
2001 Eye Street, NW
Washington, DC 20006 202/457-4900

Institute of Industrial Engineers (IIE)
25 Technology Park
Norcross, GA 30092 404/449-0460

National Computer Graphics Association (NCGA)
2033 M. Street, NW
Suite 330
Washington, DC 20036 202/466-5895

Numerical Control Society (NCS)
519-520 Zenith Drive
Glenview, IL 60025 312/297-5010

World Computer Graphics Association (WCGA)
2033 M. Street, NW
Suite 250
Washington, DC 20036 202/775-9556

American Society for Engineering Education (ASEE)
11 Dupont Circle
Suite 200
Washington, DC 20036 202/293-6080

ICAM (Air Force Integrated Computer Aided Manufacturing)
Program Office
Air Force Materials Laboratory
Wright-Patterson Air Force Base
Ohio 45433

Robotics International (RI/SME)
P.O. Box 930, Dearborn, MI 48128 313/271-1500
Library. Robotics Today, bimonthly.

American National Standards Institute
1430 Broadway, New York City, NY 10018 212/354-3300

Journals & Periodicals - Many hundreds of technical journals and other perindicals are published in this country. They are important sources of information and each school should develop a library of subscription. We are providing only a partial list. (There are at least 75 monthly magazines today dedicated to computers alone!)

JOURNALS AND OTHER PUBLICATIONS

American Journal of Physics, monthly $25
335 East 45th Street, New York City, NY 10017

American Machinist, biweekly, $25
1221 Avenue of the Americas, New York City, NY 10020

Canadian Controls and Instrumentation, monthly, $10/12
481 University Avenue, Toronto, Ontario, Canada M52 1A7

Canadian Electronics Engineering, monthly, $10/12
481 University Avenue, Toronto, Ontario, Canada M52 1A7

Computer, monthly, $30
5855 Naples Marine Plaza, Suite 301, Long Beach, CA 90803

Computer Decisions, monthly, $15
50 Essex Street, Rochelle Park, NJ 07662

Computers and Automation, 13 times/year, $18.50
815 Washington Street, Newtonville, MA 02160

Computerworld, weekly, $12
797 Washington Street, Newtonville, MA 02160

Data Management, monthly, $8
505 Busse Highway, Park Ridge, IL 60068

Datamation, monthly, $18
35 Mason Street, Greenwich, CT 06830

Design Engineering, monthly, $12/15
481 University Avenue, Toronto, Ontario, Canada M52 1A7

Design News, biweekly, $20
221 Columbus Avenue, Boston, MA 02116

EE - Electrical Equipment, monthly, no price listed
172 South Broadway, White Plains, NY 10605
(Instrument Society of America)

Electromechanical Design, monthly, $20
167 Corey Road, Brookline, MA 02146

Electronic Design, biweekly, $25
50 Essex Street, Rochelle Park, NJ 07662

Electronic Engineering Times, 26 times/year, $8
280 Community Drive, Great Neck, NY 11030

Electronic News, weekly, $9.50
7 East 12th Street, New York City, NY 10003

Electronic Technician/Dealer, monthly, $6
757 Third Avenue, New York City, NY 10017

Electronics, biweekly, $12
1221 Avenue of the Americas, New York City, NY 10020

Engineering Education, 8 times/year, $20
One duPont Circle, Suite 400, Washington, DC 20036
(American Society for Engineering Education)

IEEE Spectrum, monthly, $3
345 East 47th Street, New York City, NY 10017
(Institute of Electrical and Electronics Engineers)

Instrumentation Technology, monthly, $7
400 Stanwix Street, Pittsburgh, PA 15222

Instruments and Control Systems, monthly, $25
P.O. Box 2025, Radnor, PA 19089

Journal of the Association for Computing Machinery, quarterly, $30
1133 Avenue of the Americas, New York City, NY 10036

Machine and Tool Blue Book, monthly, no price listed
Hitchcock Building, Wheaton, IL 60187

Machine Design, 31 times/year, $20
Penton Plaza, 1111 Chester Avenue, Cleveland, OH 44114

Manufacturing Engineering and Management, monthly, $8.50
20501 Ford Road, Dearborn, MI 48128

Mechanical Engineering, monthly, $10
345 East 47th Street, New York City, NY 10017

Physics Today, monthly, $12
335 East 45th Street, New York City, NY 10017

Process Design, monthly, no price listed
221 Columbus Avenue, Boston, MA 02116

Production, monthly, no price listed
P.O. Box 101, Bloomfield Hills, MI 48013

Tooling and Production, monthly, $10
5821 Harper Road, Solon, OH 44139

Hewlett-Packard Journal
3000 Hanover Street, Palo Alto, VA 94303

Technology, bimonthly, $24
Technology Information Corporation, 2200 Central Avenue, Suite F,
Boulder, CO 80301

Tekscope - Tektronix, Inc. (customer information)
P.O. Box 500, Beaverton, OR 97077

- Colleges and University - Over the past few years many colleges and university have begun programs of special emphasis in high tech areas. It is an extremely valuable activity to involve respresentatives from local institutions of higher learning in planning a high school curriculum. Most would jump at the opportunity to help plan the programs of students who plan to apply for admission to their schools. In Georgia, Georgia Tech, Southern Tech, and most of the Area Post Secondary Vocational school are involved in offering the training required of technical workers. Many other schools offer computer related (especially programmer) degree tracks. Of special interest is the Advanced Technology Development Center (ATDC) at Georgia Tech which is the State's bellweather organization for high technology growth and development. Other schools around the country who have mounted significant programs and who could provide information are:

  Western Michigan University
  University of Bridgeport (CT)
  Carnegie-Mellow (PA)
  General Motors Institute (MI)
  Brigham Young University (UT)
  VPI (VA)
  North Carolina State
  University of Louisville
  Central Piedmont Community College (NC)
  Piedmont Technical College (SC)
  Milwaukee Area Technical College
  Macomb Community College (MI)
  Oakland Community College (MI)

Most such institutions are willing to share program information which can help secondary schools plan a viable curriculum.

Program Description

In this section we offer a brief description of how a program of pre-technical education would function if it were organized under optimum conditions:

Organization is as a special program for selected students who wish to pursue a career in a technical field and have the required abilities. Students are recruited and interviewed before being enrolled. A publicity campaign with students and parents is conducted. Students and parents are individually counseled as to program content, objectives, and post-high school educational alternatives. In many ways the program functions as do special programs of accelerated learning.

A program coordinator is assigned and teachers in the required areas are identified and enlisted. Ideally, teachers volunteer to be a part of the activity. The teachers consist of a combination of traditional academic and occupational subject area specialists.

Teachers meet together to review curriculum requirements and select a track of courses appropriate for alternative career routes (as per the examples presented in Section III). New courses are proposed and old courses amended as appropriate. Documentation in the form of course descriptions, content outlines, and course objectives are assembled into a curriculum guidebook suitable for sharing with school staff, parents, and other interested parties.

Students are scheduled into appropriate classes each quarter and this procedure is monitored by the program coordinator.

An industrial advisory committee is formed early in program development to review the curriculum and instruction process.

The program coordinator meets with representatives of post-secondary schools and colleges to cultivate avenues for articulated student flow into the appropriate curriculum for their career interest.

All teachers in the program meet regularly to coordinate learning experiences. A special project involving all students and all classes is designed and conducted once each year. Students are kept up to date on the technical work world through guest speakers and field trips. A cooperative work arrangement is designed for selected students in their senior year. Some students enter post-secondary education institutions early through some form of "senior plan."

All students are followed up on periodically after graduation and data on longitudinal outcomes maintained. This data is utilized to amend program design as needed. The total time frame for initiating and putting the program in place requires at least one full year (including summer planning time). A student would participate for at least three and preferably four years of their time in high school.

Obtaining Input from Business & Industry

The concept of technical advisory committees has been around for many years in the occupational education community. Unfortunately the degree and quality of real involvement of business and industry in the process of education has been extremely limited. The advent of the technical revolution we are now experiencing has made it a necessity to firmly establish education-industry linkages. The technical work environment changes so rapidly that there is no way educators can keep programs up to date by waiting several years for information to filter piecemeal through traditional channels into the education literature. Each program of technical preparation must have its own link with the industrial world it will ultimately support. A functioning advisory committee is therefore essential to the success of a technical preparation program.

It must be noted that the business and industrial community has shown a great deal of willingness to participate with educators as active partners in the design and implementation of effective curriculum and instruction. An indication of this is given by the quotes from William Missimer of Pratt-Whitney Corporation in the introduction to this publication. This desire to be involved is not at all atypical of leading technical organizations. There are several reasons for this interest that educators should be aware of:

1. Most "high tech" organizations have a high percentage of professional personnel who see such involvements as a part of their corporate as well as personal responsibility.
2. Industry understands full well that education for a technically competent workforce is absolutely essential to the welfare of not only their own industry but the entire American economy.

3. Most industries actively encourage and are genuinely concerned about their company and employees' involvement with the community in which they are located as a means of maintaining good public relations and hence acceptability for their products over the long term.

It is unfortunate but true, that most educational institutions do not have the same commitment to industry-education partnerships that the private sector has. One can only guess at the probable causes for such short-sightedness but some of the resistance is due to the following:

- The orientation of schools to not think beyond their mission as feeder institutions for colleges and thus concentrate on these linkages alone.
- Inadequate exposure of most educators to the world of work outside the public sector.
- An apparent fear by some educators to open up programs and curricula to any form of outside scrutiny.

The obstacles to industry-education partnerships can only be overcome by educators themselves. The resources are there, if we are only willing to use them. We put forward here some ideas and strategies which may be of benefit in setting up such formal relationships.

- A technical advisory committee must be more than a perfunctory group formed for their influence potential alone. This body should be knowledgeable enough to review and recommend courses and curriculum based on their understanding of technical occupations. It should be composed of those members of business organizations who have first hand knowledge of skills required and these usually have an engineering, production, R&D, first line supervisor or other "firing-line" job assignment as opposed to a staff or middle management position.

- The group should have a regularly scheduled meeting with a fixed agenda no less than twice per year. Additional meetings that are needed to complete assignments should be set by the group so as to be most compatible with all schedules. It is essential that such groups be organized as working bodies for the expressed purpose of having direct input into program design.
- Informal communication with and among all group members should be encouraged at any time information exchange seems pertinent. Members should be encouraged to visit the school to gain first hand knowledge of what happens in an educational environment and learn more about the realities of working with young people. By the same token, educators should as often as possible visit and observe the work environment of the advisory committee members.
- The use of a survey or "cold" communication to gather information or enlist support from industry for such matters as advisory committees are less than effective, and show a lack of sophistication to the business community. All contacts should be made in person if possible and by phone at the very least. These contacts should proceed through appropriate organizational channels beginning at the highest level unless some other personal entre has been developed.
- Be sure that the service that the advisor is rendering to the school and program is duly recognized and publicized in the name of the individual and his or her organization. Be sure also to commend the advisor in writing to his or her superiors within the company. Involve the highest level of authority within the school or system in naming the advisory committee and be sure that such formal appointment is duly registered with the advisor's organization. It is important that the educational

community be conscious at all times of the need to offer industry as much tangible and intangible return on the investment of their time and talent as is possible.

. Finally, all other efforts are for nothing, if any meeting or contact is conducted in anything less than a professional manner.

There are some important sources of information for local schools in the conduct of school-industry partnerships in our state. Some of these include:

The State Advisory Council on Vocational Education
18 Executive Park Drive, NE
Atlanta, GA 30329
(404) 894-2385
Dr. David Morgan, Executive Director
(This group provides an excellent publication on forming and using advisory committees)

The Governor's High Technology Advisory Council
1766 Twin Towers East
Capitol Square
Atlanta, GA 30334
(404) 656-2547
Dr. Raymond E. Morrison, High Technology Coordinator
(This group is the overall advisory board relative to technology and education for the Governor's Office and for the Department of Education)

The Georgia Curriculum Advisory Council for Engineering Technology
400 Courtland Building
Georgia State University
Atlanta, GA 30303
(404) 658-2500
Dr. Kenneth R. Allen, Executive Secretary
(This group is an arm of the Governor's High Technology Advisory Council and serves to review and recommend curriculum to technical programs in Georgia Area Vo-Tech Schools)

The Techniquip Foundation Research Project
Vocational and Career Development Department
Georgia State University
University Plaza
Atlanta, GA 30303
(404) 658-2500
Mr. J. D. Fowler, Project Director
(This project is developing the guidelines and procedures for a foundation involving the Business Council of Georgia for purposes of coordinating donations of material, equipment, personnel, and other contributions to the public schools and colleges)

The Atlanta Partnership of Business & Education
Georgia State University
University Plaza
Urban Life Suite 736-739
Atlanta, GA 30303
(404) 658-2557
Dr. Boyd D. Odom, Executive Director
(This group coordinates the relationship of the Atlanta Public Schools, Magnet School program with advisors from the business community)

The Teaching Team: Integrating Technical Academic Curricula

While it is possible to develop a pre-technical track by simply plugging students into appropriate classes in the subject areas mentioned in this document, the school or system that wants a program of high impact will be well advised to plan it around a carefully articulated program of instruction with specific outcomes in mind. Forming a team of teachers to work in concert with the students opting for this track is a sure way of adding to the impact and identity the program will have.

Technical subject matter in modern industry is characterized by complex systems interactions. High Technology devices such as industrial robots, and even automobiles are composed of an elaborate and highly interactive set of components under some form of sophisticated control either human, computer-aided or a cybernetic combination of the two. Electronic, fluid, mechanical, thermal, optical electro-magnetic, etc., components and systems work in concert with each other. In order to deal with such an environment a student will have to understand mathematical and scientific concepts as they occur in interrelation and are applied in mechanisms, devices, and complex systems. If this is ever to happen it is important that the teaching of such concepts be planned and conducted through an articulated multi-disciplinary approach. There is further, perhaps no more important concept in education for technology than to understand that the present technological revolution in American (and worldwide) industry is characterized and literally driven by the immediate application of new knowledge to some practical product or outcome. The frontiers of science and the frontiers of engineering are virtually one and the same, for almost as soon as any new conceptual breakthrough is made, someone designs something

that employs it in the real world. And indeed the converse is true. Just as the demand for cures to deadily diseases has driven research in the medical sciences so has the demand for smaller, faster, and cheaper electronics products driven research in the physical sciences.

It is consequently long past time that scholars and educators in mathematics and scientific disciplines understand that their subject matter should no longer be taught without concrete experiences in the utilization of these concepts in the real world. It is for this reason also that the concept of the teaching team is so important to education for technology. A teaching team can insure that what is learned in one subject area is reinforced and applied as appropriate in all others.

The team concept could function according to the following scenario:

> The team would consist of one teacher (or more as needed) from math, physics, electronics, computer programming, drafting, and design. Teachers would schedule weekly meetings to plan activities, so that lessons in one area are supported by other areas. That is, appropriate math concepts are learned before they are needed, or as they are needed, in physics. Appropriate subjects such as magnetism, work and power, resistance etc. are in turn covered in physics before, or as, they are needed in DC electricity. Instructors would also insure that as topics are learned in the classroom, appropriate opportunity for application of these concepts is provided in lab courses through experiments and activities. At least once each year instructors might plan a project that could be worked on across all classes such as the design, analysis, construction, testing and test reporting of a simple device. The teaching team would in short, assure that the

applications of all knowledge gained reinforced theory, and that students became aware early on, of the interdisciplinary nature of technical problem solving. Vocational laboratory classes in many areas including electronics, electro-mechanical, automotives, metals, and most others provide a natural opportunity for the application of math and science concepts to work world problems. For this reason it is important that pre-technical education be viewed as a combined vocational-academic activity.

The integration of technical and academic curricula is facilitated by the leadership of a local advocate. This staff member must have established personal and professional credibility with the administration and teaching staff of the local secondary school. This individual must be enthusiastic and dedicated to the idea that technical education is indeed the applications laboratory for the concepts presented in the academic arena. The ability to mold a working team is an important characteristic of the leader who takes on the role of integrator.

A working relationship and coordination of efforts should be established between the integrator and the chairman of the math OR science department (the personalities of the individuals will somewhat determine which of these occurs first) so that follow-up efforts for a larger team will have impetus from two enthusiasts. In order to achieve the desired results, the individuals/department chairmen who work on this integrating team must be personally motivated rather than assigned to the effort. It is possible that in some settings, the department chair is NOT the person to represent an academic area. However, it would be advisable to assure that the chairman is informed about any formal activity which might have impact on the department.

Just as important is the premise that the integration takes place through the efforts of a TEAM and not a committee. Maybe there should be no formal identification of the group until after it is successful, not before. Trying to define chemistry within a working, successful team is difficult, if not impossible. It is likely that a person from the technical areas could generate more personal motivation for the effort since traditionally the academic areas have 'credibility' conferred on them by default, and the technical staff is at a distinct disadvantage in most local buildings.

The local advocate needs to accept the possibility that the integrating efforts will take a while to start to show results. The team members must realize that informal influence on students is often stronger than formal classroom presentations. The student network spreads the good or bad word about the value of courses and the professional integrity of specific teachers. Therefore, it is extremely important that team members be selected who work well with students and have established credibility in their subject area. If these characteristics are combined with some professional experience in the 'work world,' the team candidate will provide invaluable expertise to the integration effort.

Inter-departmental dialogue will increase and improve with participation in other department staff meetings. The use of this technique requires personal trust between the hosting chair and the visitor. Visiting as an observer on several occasions prior to 'speaking up' will enhance the chances of success in continued dialogue.

The sequence of activities to initiate and consummate an integration effort follows:

1. Coordinator of integration is selected or volunteers when made aware of potential advantages of effort.

2. Coordinator established dialogue with one other technical department.
3. Two departments identify commonalities in subject matter.
4. Chronology and inter-meshing of shared/common skills are identified.
5. Specific technical laboratory activities are identified which would reinforce concepts through 'hands-on' experience.
6. Teaching methods are shared between departments to assure that similar subject matter is being presented clearly by both groups. An example of this is the universal need for scientific notation and the countless ways it can be taught. The plan is not to teach the same way in all classes since students learn in one setting when it is confusing in another. But, time spent unlearning/relearning the same skill is precious time which could be used in more productive ways.
7. Technical teachers help academic teachers formulate 'work world' examples. A repertoire of good, realistic problems takes time to accumulate, and the time spent by the academic teacher could be reduced if assistance is available. Common terminology exists throughout the technical, scientific, and mathematical areas of expertise, and 'singing off the same sheet of music' is important.
8. Technical teachers must establish personal credibility with their academic counterparts so that academic teachers can recommend, in good faith, that their students take classes in the technical area. In many schools, there is academic and social stigma associated with taking classes in the non-academic courses. The technical teachers must be sure that their expertise and classroom management are beyond reproach until the time that some of the stigma and prejudice are eradicated . . . they must be better just to stay even.
9. When most of these ideas have been implemented successfully, it is time to involve the third department and repeat the sequence with two

experienced enthusiasts and a novice.

Mathematics should assume the linking function between academic and technical education at the secondary level. Its role as the tool of scientific application, communications link, and international language of scientists places upon it the responsibility for wedding these areas of expertise.

When a student studies pH in chemistry, he must have some concept of logarithms. If the study of chemistry precedes the introduction of logarithms in the mathematics curriculum, then the responsibility for teaching the mathematics skill rests with the chemistry teacher. The interweaving of skill application precludes any perfect sequence so that every skill in every area falls at exactly the desired place.

The concept of scientific notation and number of significant digits is used in chemistry, physics, electronics, and computer programming. If the instructor in each of these courses waits for someone else to teach the concept, the curriculum sequence log jams. All teachers in the academic and technical arenas must have the supporting skills to teach, to some extent, a valid approach to these interrelated concepts.

Triangles are used in drafting, trigonometry, and physics, to name a few, but who is to be responsible for introducing the concept? If a student works with triangles in drafting, he will probably understand it more thoroughly when the mathematics teachers introduce and expand the concept.

Much of the secondary school physics curriculum is based on non-calculus concepts and derivation. Has the physics teacher over-simplified when he explains the vertical path of a tossed ball without mentioning that velocity and acceleration are the first and second derivatives of the equation of motion which describes that path? Probably not, but if

incorrect and/or misleading information is given to justify the explanation, the student is placed in a position of having to decide which teacher is giving out correct information. Most secondary students would neither understand nor appreciate scientific study if they had to have post-secondary skills to register for the class. Most secondary schools cannot accommodate two levels of physics instruction, so communication between departments is vital. Neither department is 'right,' but the student must not be placed in the untenable position of having to make a choice.

The development of good problem solving skills and accurate arithmetic manipulation skills becomes the responsibility of all who guide students' learning. It is unthinkable that technology, scientific, or mathematical exercises are conducted without taking advantage of calculators and other electronic devices which remove the minutiae and boredom from the pursuit of knowledge in these areas. These devices should not substitute for, but should enhance, the acquisition of skills.

The electronic computer has become a cost-effective tool for assisting the mathematician who in turn assists the scientist. The prevalence of the micro-processor puts vast capability at the fingertips of those who learn to take advantage of it. This is not to say that everyone should become a programming specialist, but the use of prepared software and some facility with computer hardware are vital to the support of technical and scientific effort.

The chart which follows shows the relationship of skills in the areas of mathematics, science, and technical expertise.

Interrelationship of Skills

MATHEMATICS	SCIENCE	TECHNICAL
Critical Thinking	All areas	All areas
Problem Solving	All areas	All areas
Measurement	Physics Chemistry	Drafting Electronics
Estimating	All areas	All areas
Algebra		
Interpolation	All areas	Electronics
Computation	Chemistry	Electronics
	Physics	Computer Programming
Scientific Notation	All areas	Computer Programming Electronics
Significant Digits	Physics	Computer Programming
	Chemistry	Electronics
Scale Factors	Physics	Computer Graphics
Geometry		
Angles	Physics	Drafting
Triangles	Physics	Drafting
Lines/Curves	Physics	Drafting
2-Dimensional Space	Physics	Computer Graphics Drafting
3-Dimensional Space	Physics	Computer Graphics Drafting
Numeration		
Numbering Systems		
Binary		Computer Programming Electronics
Octal		Computer Programming
Hexadecimal		Computer Programming
Electronic Calculator	Chemistry	Computer Programming
	Physics	Electronics
Simulation	All areas	All areas
Trigonometry		
Functions of angles	Physics	Computer Graphics
Translation of axes		Computer Graphics
2-D Rotation		Computer Graphics
3-D Rotation		Computer Graphics
Calculus	Advanced Physics	Computer Programming
Numerical Analysis		Computer Programming

Application/Problem Solving In A High School Pre-Tech Program

As mentioned above in this document, a team approach to a high-tech curriculum will greatly enhance the student's preparation for a technical career. Mention has been made that the needed mathematics should precede the use in physics, and that the required physical principles should precede their application in electrical, and so on.

Further strengthening of the technical preparation can be easily gained by examining each discipline to ascertain applicability of theory to actual, real-world uses. For example, when teaching sine, co-sine and tangents in trigonometry the instructor could show their application to advanced drafting techniques, their uses in machining and NC programming, as well as some applications in electronics.

The mathematics teacher will need to work very closely with the experts in the other disciplines to discover relevant applications; however, rudimentary technical applications should be well within the capability of a good mathematics instructor. Motivation to learn, attention and retention of mathematic principles will be strengthened if the student can see that they are relevant to other studies and that they are tools with universal application.

Physics should be taught utilizing the unified concept (Unified Technical Concepts). In the unified concept all the major physical principles (such as force) are taught successively across four physical domains - electrical, mechanical, fluids and heat.

As with mathematics, each new principle should be made relevant through commonly recognized application(s). For example, moment arms could be illustrated in terms of torque wrenches. A torque wrench can

be fully conceptualized with a standard pull handle and a spring scale ("fish scale"). Each time a principle is mastered, problem solving should be the capstone of the presentation. For example, in the torque wrench exercise, the finale could be to determine how many pounds of force (at the handgrip) are needed on an actual torque wrench to achieve a certain torque output.

The point of using the moment arm/torque exercise is that principles are related to a useful purpose: Thoroughly understanding moments of force acting on an arm, how they translate to torque, how torque is measured and above all how to improvise an acceptable torque wrench! Empty theory has been foiled again!

Graphics can also benefit from relating principles to applications. Principles learned in geometry and trigonometry can be directly incorporated into schematics and simulated mechanical parts and devices.

For example, a theoretical (simple) electrical circuit design can be assigned in physics or electrical class. Simultaneously, the graphics assignment could be to do the circuit in a neat, professional schematic, utilizing standard symbols and notations. Or, suppose that fluids are being studied and the physics teacher challenges the student to construct a simple hydraulic jack, calculating the areas, pressures and volumes needed to lift a certain weight. The graphics application could be to draw (to scale) the jack in standard 3-view format. (Allowance would be made for lack of knowledge concerning seals, threads, etc, but areas, strokes, moment arms, etc. would be required to be accruate).

The computer could be used to build an "engineering" or "project" notebook (similar to that required in engineering and technical schools). Given adequate software, the computer could also be used for long cal-

culations, graphics and machine control programming (all highly relevant, demonstrative uses of computer).

In tune with applications and problem solving, the creative instructor often challenges students with "fun" projects. Such events are highly motivating and often elicit amazingly creative solutions to the problem(s) presented.

For example, when exploring acceleration and deceleration, a project could be to calculate the velocity of an egg dropped from a certain height; then, given certain materials, devise a way to decelerate and stop the egg without breaking it. (A successful student might then be asked to estimate the distance and rate of deceleration of the egg). The project could be presented as a contest, with prizes awarded the winners.

With some thought and planning "fun" projects could involve more than one teacher. The egg example could be assigned by the physics instructor, the design drawn in graphics and the technical report written and edited on computer.

In summary, the dedicated, imaginative staff of a high-tech high school will take every opportunity not only to have their courses highly articulated and interrelated but also will assure that mathematical, physical and scientific principles are presented in terms of real-world applications. Further, each principle learned would subsequently be presented in a problem solving context (realistic, not highly contrived and unlikely to occur in actual fact).

The key words in all studies are: relevancy and problem solving. (For a discussion of how important this improvisational problem solving approach is to the scientific and technical worker in modern high tech companies see Michael Maccoby's discussion of "The Craftsman" in his renowned treatise on management character types, The Gamesman.)

Equipment & Materials

Very often technical programs require materials and equipment of a very specialized nature. Research done by the High Technology Project over the past 3 years has uncovered certain specific resources which may be of value to the local school attempting to develop programs. While not an exhaustive list the following sources, in addition to the organizations and publications mentioned in Part I of this section, can provide information, materials and equipment. It should be noted that the provision of vendor services to technical education programs has become major new market of enormous interest to many materials and equipment houses of long standing. It has also spawned the typical proliferation of new business ventures. Each purchaser must be cautious to carefully evaluate products before they are purchased. It is also important to note that most of the activities that are conducted at the high school level can be done without inordinate investments in hardware. The most expensive investment will probably be in micro-computer systems and software including computer aided design programs such as CAD-Apple which are currently available. Educational institutions have recently been targeted for drastic price discounts in computer hardware and software by a number of major vendors.

Educators should also be aware that equipment and materials are dated rapidly in technical work. Whatever is purchased must be evaluated in light of its ease of upgrade. A major source of printed material should be articles from current journals and periodicals reprinted by permission.

Equipment & Training Systems Vendors

Feedback, Inc.
620 Springfield Avenue
Berkeley Heights, NJ 07922
201-464-5181

Technovate, Inc.
910 Southwest 12th Avenue
Pompano Beach, FL 33060
305-946-4470

Heath Kit Zenith
Educational Systems Division
P.O. Box 167
St. Joseph, MI 49085

Amatrol
P.O. Box 2097
Clarksville, IN 47130
812-288-8285

Amptronics
401 W. Salem Avenue
Arlington Heights, IL 60005
312-876-0883

Festo Didactic
395 Moreland Road
Hauppage, NY 11788
516-435-0800

Anilam Electronics Corp.
5625 NW 79th Avenue
Miami, FL 33166
305-592-2727

Brodhead-Garrett Co.
2448 Industrial Park Drive
Macon, GA
912-781-8952

TPC Training Systems
1301 S. Grace Avenue
P.O. Box 1030
Barrington, IL 60010

Tel-a-Train
309 North Market Street
P.O. Box 4752
Chattanooga, TN 37405
615-624-2628

Atlanta Fluidpower Sales
2264 Northwest Parkway, Suite G
Marietta, GA 30067
800-282-2553

Lab-Volt
Dixie Educational Systems
4814 Highway 78
Lilburn, GA
404-979-4244

Learning Labs, Inc.
Electronic Training Systems
Box 122
Calhoun, GA 30701
404-629-4624

Lab Fabricators
1802 East 47th Street
Cleveland, OH 44103

Hickok Learning Systems
2 Wheeling Avenue
P.O. Box 2127
Waburn, MA 01888
617-935-5850

Allison Associates
Box 313
Troy, MI 48099
313-689-2990

Hampden Engineering Corporation
99 Shaker Road
P.O. Box 563
East Longmeadow, MA 01028
413-525-3981

In addition most major producers of technical equipment such as Apple, IBM, Hewlett-Packard, Digital Equipment Corporation, Control Data Corporation, and others have large Educational Products Divisions.

Publishers

Addison-Wesley Publishing Company, Inc. (617) 944-3700
Jacob Way
Reading, MA 01867

American Technical Publishers, Inc. (312) 371-9500
12235 South Laramie Avenue
Alsip, IL 60658

Ballinger Publishing Co. (617) 492-0670
54 Church Street
Cambridge, MA 02138

Bobbs-Merrill Educational Publishing (317) 298-5517
4300 W. 62nd St., P.O. Box 7080
Indianapolis, IN 46206

Byte Publications Inc.
70 Main Street
Peterborough, NH 03458

Computeach Press (408) 997-3104
P.O. Box 20851
San Jose, CA 95120

Computer Science Press, Inc. (301) 251-9050
11 Taft Ct.
Rockville, MD 20850

Delmar Publishers Inc. (518) 459-1150
50 Wolf Road
Albany, NY 12205

Digital Press (617) 663-4124
12A Esquire Road
Billerica, MA 01862

Elsevier Science Publishing Company, Inc.
52 Vanderbilt Avenue
New York, NY 10017

Gardner Publications, Inc. (513) 231-8020
6600 Clough Pike
Cincinnati, OH 45244

Harper & Row Publishers, Inc. (212) 593-7000
10 E. 53rd Street
New York, NY 10022

Publishers

Heyden & Son, Inc.
247 S. 41st Street
Philadelphia, PA 19104
(215) 382-6673

Houghton Mifflin
One Beacon Street
Boston, MA 02108

Industrial Press Inc.
200 Madison Avenue
New York, NY 10157

John Wiley & Sons, Inc.
605 Third Avenue
New York, NY 10158
(212) 850-6418

Little, Brown & Company
34 Beacon Street
Boston, MA 02106
(617) 227-0730

McGraw-Hill Book Co.
1221 Avenue of the Americas
New York, NY 10020
(212) 997-1221

MIT Press
28 Carleton Street
Cambridge, MA 02142
(617) 253-2884

Osborne/McGraw-Hill
630 Bancroft Way
Berkeley, CA 94710

Pergamon Press Inc.
Maxwell House, Fairview Park
Elmsford, NY 10523
(914) 592-7700

Plenum Publishing Corporation
233 Spring Street
New York, NY 10013
(212) 620-8000

Prentice-Hall, Inc.
Route 9W
Englewood Cliffs, NJ 07632
(201) 592-2000

Princeton University Press
41 William Street
Princeton, NJ 08540
(609) 452-4900

Publishers

Productivity International Inc.
5622 Dyer St., Suite 220
Dallas, TX 75206

Reston Publishing Company, Inc. (703) 437-8900
11480 Sunset Hills Road
Reston, VA 22090

Robert E. Krieger Publishing Company, Inc. (305) 724-9542
P.O. Box 9542
Melbourne, FL 32902

SEAI Institute
P.O. Box 590
Madison, GA 30650

Society of Manufacturing Engineers (313) 271-1500
One SME Drive, P.O. Box 930
Dearborn, MI 48128

South-Western Publishing Co. (513) 271-8811
5101 Madison Road
Cincinnati, OH 45227

Sterling Swift Publishing Co. (512) 444-7570
1600 Fortview Road
Austin, TX 78704

St. Martins Press
175 Fifth Avenue
New York, NY 10010

Synapse Information Resources, Inc. (607) 748-7885
912 Cherry Lane
Vestal, NY 13850

Texas Instrument Learning Center
P.O. Box 225012 MS-54
Dallas, TX 75265

Van Nostrand Reinhold Co. (212) 265-8700
135 W. 50th Street
New York, NY 10020

APPENDIX A

Appendix A

UTC Physics Description

UTC Physics

A special word must be said about the physics program in our curriculum. Unified Technical Concepts will be the vehicle by which math, physical laws, and dynamic technical systems will be interrelated.

UTC is different from other physics courses in that it approaches the subject from the standpoint of 13 concepts, each of which has applications in thermal, fluidal, electrical and mechanical systems. By first learning the concept and then its application in laboratory exercises across the various systems the technician prepares a knowledge base for all the sorts of interactions to be encountered in the complex technical environment of today. The following description will acquaint you in more detail with these concepts.

Thirteen concept modules form the backbone of UTC. Each of these modules presents a single concept and discusses the application of that concept in each energy system.

1-0 FORCE

This module describes forcelike quantities as "the physical quantities that produce motion." The following forcelike quantities are discussed:

Mechanical - force and torque.

Fluidal - pressure difference.

Electrical - potential difference.

Thermal - temperature difference.

2-0 WORK

"Work" is defined as "the product of a forcelike quantity and a displacementlike quantity" in each energy system.

3-0 RATE

"Rate" refers to "the quotient of a displacementlike quantity and elapsed time" in each energy system.

4-0 MOMENTUM

"Momentum" is defined as "the product of mass and velocity" in mechanical and fluidal systems. Electrical and thermal systems are not discussed as momentum analogies because these systems are beyond the scope of UTC.

5-0 RESISTANCE

Static and sliding friction are investigated as examples of resistance in mechanical systems. For other energy systems, resistance is defined as "the ratio of forcelike quantity to rate."

6-0 POWER

"Power" is "the rate of doing work" in each energy system. The efficiency of devices that convert power from one form (energy system) to another is defined and discussed.

7-0 POTENTIAL AND KINETIC ENERGY

This module describes potential and kinetic energy in each energy system, the conservation of energy and Bernoulli's equation in fluidal systems.

8-0 FORCE TRANSFORMERS

"Force transformers" are defined as "devices that transform an input forcelike quantity and displacement into a different output forcelike quantity and displacement in the same energy system

(levers, hydraulic jack, electrical transformers)." Thermal systems are not discussed, as there are no transformers of temperature difference.

9-0 ENERGY CONVERTORS

The operation and efficiency of devices that transform energy from one energy system to another are described in this module. A wide variety of energy convertors are discussed. Optical (light) energy is included in this concept as a fifth energy system.

10-0 TRANSDUCERS

"Transducers" are defined as "devices that change information-carrying signals in one energy system to signals in mechanical, electrical, or fluidal systems." The operations of several important transducers in each energy system are discussed as examples.

11-0 VIBRATIONS AND WAVES

The basics of wave behavior with examples in mechanical, fluidal, and electrical systems are explained. The discussion includes the wave equation, superposition, and interference of waves.

12-0 TIME CONSTANTS

In this module, an explanation is given of time constants used to describe exponential increase and decrease functions in all energy systems. Radioactive decay is included as an additional example.

13-0 RADIATION

Both electromagnetic and particle radiation are explored in this module, which is organized under these two topics rather than under the usual energy systems. Properties of electromagnetic radiation discussed include the inverse square law, polarization, reflection, and refraction.

To conclude our discussion of the systems approach we will use an example of the way a technician might apply knowledge of a single unified technical concept to understand relationships within a device or process exemplifying several systems.

One of the unified concepts is real opposition, or resistance. An explanation of how the cross-disciplinary nature of this principle is applied may be illustrated as follows.

Because there is a well-known definition for electrical resistance, we may start with

$$R_{(elect)} = \text{volts/ampere}$$

Then, by multiplying numerator and denominator by time, we obtain

$$R_{(elect)} = \frac{(\text{volts})\ (\text{seconds})}{(\text{ampere})\ (\text{seconds})} = \frac{\text{volt - seconds}}{\text{coulombs}}$$

We might then generalize to obtain a universal definition of resistance. Volts can be considered electrical pressure, and most frequently this equation will be applied to cases where there is a difference in pressure of force. Therefore, the numerator is converted to a difference in pressures. In place of the electrical quantity expressed in coulombs, we might divide the numerator and denominator by time and convert the coulumbs/time to quantity/time, with the result that

$$\text{Resistance} = \frac{(\text{pressure}_1 - \text{pressure}_2)}{\text{quantity/time}}$$

This single definition can then be used for thermal, hydraulic, electrical, and pneumatic phenomena. Regardless of the type of energy involved (excluding chemical and potential energies), there cannot be a transfer of energy from one location to another without having a difference in levels exist. It always takes time to effect this transfer, and some definite quantity must be involved in the transfer. As the

student attempts to work in several fields. he is aided if he can see that the various types of systems all follow the same basic laws.

In the situation dealing with heat, thermal resistance is measured by the temperature differential and the time required to transfer some amount of heat. Perhaps it is more evident in the thermal case than in the electrical example that there is always a difference in the temperatures which governs the rate at which heat is transferred from one point to another. If one assumes that when one temperature is 400 degrees and the other is 200 degrees, 200 Btu are transferred in an interval of 10 minutes, for example:

$$R_{thermal} = \frac{(T_1 - T_2)\ (time)}{quantity\ of\ heat\ transferred}$$

$$R_{thermal} = \frac{(400\ deg - 200\ deg)\ (10\ min)}{200\ Btu}$$

$$R_{thermal} = \frac{(200\ deg\ differential)\ (10\ min)}{200\ Btu}$$

$$R_{thermal} = \frac{(10\ deg)\ (min)}{1\ Btu}$$

or with seconds as the measure of time this becomes

$$R_{thermal} = \frac{(200\ deg)\ (600\ sec)}{200\ Btu}$$

$$R_{thermal} = \frac{(600\ deg)\ (sec)}{1\ Btu}$$

A fluid cannot be made to flow through a pipe or conduit unless there is some differential pressure available to overcome the resistance or retarding effect of the conducting tube, pipe, or vessel. Thus, in the fluid case, with either liquids or gases, we know that a differential pressure is required to establish some given rate of flow. For example, if the inlet pressure to a pipe is 50 psi, and the pressure 40 feet downstream is 45 psi when a fluid is flowing at the rate of 20 lb/min,

then the resistance of that section of pipe is easily ascertained from our definition.

$$R = \frac{\text{differential pressure}}{\text{rate}}$$

$$= \frac{\text{(differential pressure)}}{\text{quantity/time}}$$

By simple algebraic manipulation this becomes

$$R = \frac{\text{(differential pressure) (time)}}{\text{quantity}}$$

$$R = \frac{(50 \text{ psi} - 45 \text{ psi})}{20 \text{ lb/min}}$$

$$R = \frac{5 \text{ psi}}{20 \text{ lb/min}} = \frac{0.25 \text{ psi}}{1 \text{ lb/min}}$$

This means that there is a quarter of a psi pressure drop for each lb/min change in flow rate.

When dealing with different types of flow situations, whether we are concerned with electrical, thermal, hydraulic, or gaseous conditions, the same relationships hold. Consequently they may all be expressed the same way.

If we use the basic concept that it is a "difference in pressure level," whether it be electrical pressure in volts, thermal pressure in terms of degrees, or pressures in pounds per square inch, then a single type of elementary circuit can be used for all of these fundamental relationships. In some cases, El_2 might be zero.

But such a simple circuit goes far beyond "resistance" relationships. Mastering its concepts paves the way to the understanding of direct-current motor controls which are based upon the difference between the impressed and the self-generated internal counter-electromotive force. Electrical transformer action also depends upon this "difference" of

potentials. In the case of the saturable reactor, one of the potentials is caused to go to zero at some desired moment. Thus one simple relationship can be used over and over again to explain hydraulic, electrical, and thermal relationships and phenomena.

APPENDIX B

APPENDIX B

This appendix contains a career decision model that can be used as a handout or information sheet to assist students in a career guidance session. Career guidance is an essential function in a pre-technical program. At some point, possibly in the Survey Course in Engineering, Science, and Technology, students should "walk through" a career decision making process. This is a good time to employ a resource person from the guidance staff. The poor career development of high school students is one of the greatest disservices that has ever been done to young people. A career for most people today, is that thing which defines them as human beings. There would seem to be no more important function of schooling than to prepare youngsters very carefully for what they will be doing for the rest of their life. Unfortunately, we most often prepare them only for more schooling.

Appendix B

HOW DOES A PERSON DECIDE IF A CAREER IS RIGHT OR NOT?

This extremely important question is being asked these days by many people from all age groups and from all walks of life. Remember that your career is a strong and definite statement that you make about who and what you are in this world. A career decision should be made carefully with a lot of thought and with a lot of information. Since you are enrolled in this course you obviously have made a choice, by some means or another, to pursue an education for technical careers. Throughout your career, you will be faced with making choices about your future. Should I work for this company or that company? Should I go into design work or not? Should I become a manager? Should I go out on my own? What about my family? Are they part of my career decision? In this section, we present some background information and a decision-making model for career choice that can be used by anyone. You will notice that the model used (Figure 1) closely resembles the flow chart sort of diagram used to develop computer programs. The human mind is really the most complex computer of all and people think much like a computer "thinks." We all must deal with yes-no, and go/no-go kinds of questions. A computer has a lot of trouble in programming a "maybe" and so do people. Let's look, then, at a way to realistically evaluate any career decision.

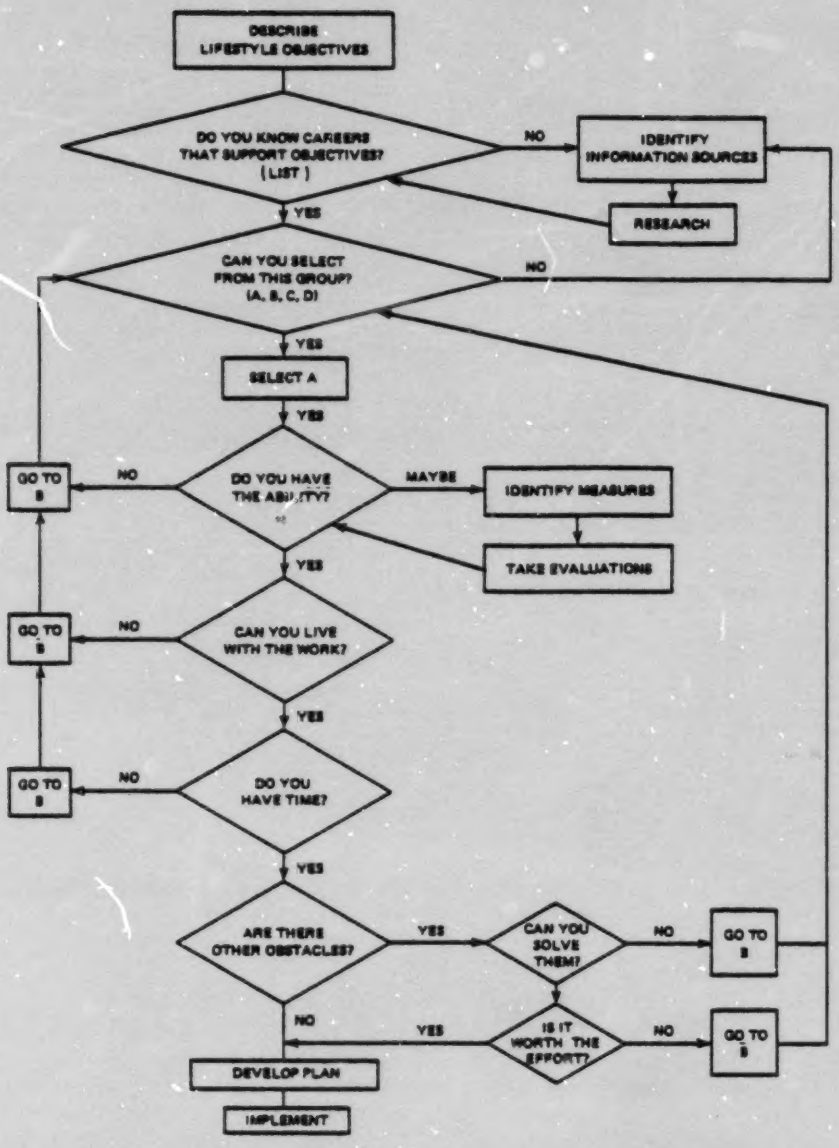

Fig. 1 A pragmatic model for career decision making.

QUESTION I: WHAT DO I WANT MY LIFE TO BE LIKE?

Contrary to some career decision models, this one does not begin by asking you to think specifically about a job. There are probably a number of jobs with which you could be happy. Conversely, there is probably no one job with which you will be completely happy all the time - even though that may be your goal. In order to make a career choice realistically, you must examine something more fundamental than what kind of work you want to do; you must confront the more basic question of how you want to live.

Try to describe and write down what you want your life to be like, and consider at least the following five subquestions.

What "Things" Do I Want?

What kind of house do I want to live in? What kind of car do I want to drive? What kinds of things (which cost money) do I want to be surrounded by. Try to be as specific as you can right down to the carpet on the floor and the car(s) in the garage. The real question that you probably will have to confront on this point is - "How much money will I have to make to have all these things?"

What Kinds Of Relationships With Others Do I Want?

This is an extremely critical question. Your work affects your ability to have certain kinds of relationships. For example, a person who travels a lot in a job gives up time with his or her family, and there is no way around it. Try to describe the kinds of relationships that are important to you in terms of spouse, kids, parents, friends, coworkers, and anyone else. Your career will directly influence the kinds of people you are around and how much you are around them.

What Sort Of Life Will Be Self-Fulfilling For Me?

This a difficult and somewhat philosophical question, but it lies at the heart of many, many decisions in all areas of life. More simply put, it means "What will I have to be, do, and have to feel good about me?" This question involves the level of success, achievement, recognition, or reward that is important to you. It also includes finding out what signifies or represents success to you. It involves the question of "Where does my sense of self-satisfaction come from?" This is a question you may need help in clarifying, and it is good to talk it over with other people that you trust such as parents, friends, teachers, counselors or whosoever's opinion and advice you respect.

What Do I Want To Be Able To Do With My Time?

This question is intended to get at the idea of flexibility in life-style. Work will have a direct bearing upon how much time you have to do things that are important to you. Maybe you had rather work more than have free time. Vacation time, length of work day, even length of work year all are important to this question. Everyone has a personal view of how he or she wants to spend time, and how much time on what activity. Getting clear on this issue can definitely influence a career decision.

What Do I Want My Surroundings To Look Like?

This question involves things like what part of the country you like best, whether you prefer rural, urban, or suburban settings and so forth. It also involves more direct questions about work such as indoors, outdoors, office or factory, and so on.

The answers to all these questions will require a series of personal and perhaps family trade-offs and negotiations. There is probably no person living who has achieved exactly what he or she wants on all these dimensions. There are also many people we would consider wildly successful in achieving their life style ambitions who are profoundly unhappy. What each person must do is settle on personal criteria for what a "good enough" life is, and then go out and get it. These criteria for "good enough" life must precede a specific career decision and they have definite implications for career choice as you can see.

QUESTION II: WHAT CAREERS ARE CAPABLE OF SUPPORTING MY LIFE STYLE OBJECTIVES?

This question requires that a certain amount of information be collected from various sources. When life objectives have been identified and written down in priority order, the information gathered about various careers can be compared with them. In this way differences between what we want from our life and the specific characteristics of various careers can be evaluated.

There are a number of ways you can collect more specific information about the nature of various occupations. Possible sources include:

- Career publications such as the Dictionary of Occupational Titles, The Occupational Outlook Handbook, as well as many similar books available through typical school guidance offices and libraries.
- Career fairs or seminars organized by schools, churches, civic groups, and other organizations, where representative individuals from numerous job roles share personal insight and information.
- Personal contacts with job incumbents. This approach to seeking information probably is the most common and the most poorly done. Family, friends, teachers, social contacts, business contacts, all are potential sources of information. This kind of search can be the most beneficial if it is planned and systematic with specific questions, formulated on the basis of life objectives, prepared ahead of time.

- Formal career counseling either through paid consultation, visits to school guidance offices, or use of community organizations who sponsor such activities.

The research conducted above should address and hopefully answer questions about salary, working conditions, free time, fringe benefits, nature of the work (Is it fun and why?), and so on. The career decision-making process cannot be any better than the quality of information we are able to gather about jobs. The sad reality, however, is that many people rely on their personal opinion and projections of what they think a job entails. This kind of "armchair quarterbacking" is usually little more than fantasizing and no more valuable to a real career search than daydreaming.

QUESTION III: CAN I SELECT FROM THIS GROUP?

This question is a definite decision point. It requires that you put all your information about yourself and the work world together, write down the careers that appear to meet your needs and make a Probable Best Choice (PBC). If you still cannot reach PBC (your answer to question III is no), go back to question II. If you can select a PBC, go to question IV.

QUESTION IV: DO I HAVE THE ABILITY TO PERFORM IN THIS CAREER?

This question brings you to the ability assessment portion of the career decision process. As you collect the job-specific information in Question II, you collect information on what sort of things are required to be hired. This includes training and educational requirements and the like. It also should include enough about the skills required for you to make a fairly accurate decision about whether you feel you have the ability. Ability assessment can be a problem, however. Most

people underestimate or ignore facets of their own ability. You may never know what you can do unless you apply yourself. If you are in question about whether you have the ability there are several standard ways to test yourself as follows:

1. Scholastic aptitude tests which measure the ability to succeed in academic areas required in the career.
2. Vocational and general aptitude tests which measure motor skills (hand to eye, etc.) and other specialized skills necessary for a career.
3. Personality inventories which evaluate your personality characteristics and compare them to those of people who are successful in a specific career.

All of the above are available from most school counseling offices and from some private career counselors. When in doubt, assume you do have the ability and evaluate yourself on the proper test. Remember that in many ways, desire is more important that ability.

If you find that your answer to question IV is no, go back to question III, select your next PBC, and continue.

QUESTION V: CAN I LIVE WITH THE WORK DAY IN AND DAY OUT?

This may seem to be a strange question. It might also seem to come somewhat late in the decision process. Many career decision models actually start with this question. They try to take elements of an individual personality and assess whether or not they are compatible with <u>the nature of work</u> performed in a given job. The model we have been using assumes that most of us could be happy with many different kinds of work if the job itself met more basic motivations and objectives in our lives. The nature of the work question must be carefully considered,

however. Many of us would be happy with the kind of life that the career of neurosurgeon provides and we might have ability and time to reach that goal, but if we faint at the sight of blood, this is hardly a realistic choice.

At this decision point, ask yourself a series of subquestions such as:

- Is the setting in which the work is performed acceptable to me?
- Are there restrictions in time, flexibility, movement, etc., which are offensive?
- Is the specific conduct of the work unbearably arduous, boring, etc?
- Can I really enjoy doing this sort of thing day in and day out? Will it be exciting and "enough" fun to meet my other objectives?
- Can I be good at this job?

It is the carefully considered opinion of the authors that unless the answer to at least that final question "Can I be good at this job?" is yes, you will never be satisfied with the work you do no matter what seeming reward it offers.

Again consider all these questions carefully. Return to Question III if the answer is no. Proceed if the answer is yes.

QUESTION VI: DO I HAVE THE TIME TO REACH MY CAREER CHOICE GOAL?

This question is much more critical for people making a career choice or career change in mid-life and beyond. Very often certain careers require an amount of training or preparation time that is unrealistic for some people at a given age. This is purely an individual assessment. Most people in their twenties feel they have the time to reach virtually any career goal, and they probably do. Career time, as the term is used here, has several components:

- Exploration time - time needed to make a choice.
- Training time - the time needed to get the necessary skills.
- Search time - the time needed to find employment.
- Development time - the time to work at the job to meet a desired personal level of success based on life objectives.

If the answer to Question VI is no, return to Question III.

QUESTION VII: ARE THERE OTHER OBSTACLES?

There could perhaps be other barriers not previously mentioned in the decision model. Such things as family wishes, spouse's career, and physical handicaps could stand in the way of a career. At this point a person must decide if the PBC selected is worth the effort in overcoming any remaining obstacles. If the answer is no, the next choice is selected beginning as usual at Question III.

THE IMPLEMENTATION PLAN

When a decision has been reached via the above process, all that remains is the implementation of that decision. In order to achieve a career goal, it is best to develop in some way a plan that spells out what activities and outcomes are planned. This may seem like an unnecessary step, but it can do a great deal to clarify the process and to keep objectives clearly in mind. The career decision choice process will most likely occur several times in the average person's working lifetime. A reassessment of life objectives will be necessary and change in the nature and importance of certain items is to be expected. A clear-cut plan is always an asset in keeping life's daily processes and tasks in perspective with an overall direction.

A career implementation plan might contain the following sorts of items:

- A list of life objectives and goals.
- Methods and sources for obtaining necessary training and education.
- Time frames for achievement of certain objectives.
- Potential sources of suitable employment.
- Ideas for conducting a job search and interview campaign.
- The names of persons who wish to help or give information in a career search.

The success of the implementation plan and the securing of job satisfaction will depend upon points to be covered in the next section dealing with characteristics of successful career people.

I WANT TO PROGRESS AND GROW ON MY JOB. HOW DO I DO IT?

Job dissatisfaction and frustration is an important question that psychologists and sociologists have been intensively examining in recent years. Most psychologists would agree with a definition of job satisfaction that says job satisfaction = $\frac{\text{reward attained}}{\text{reward expected}}$. When attained reward is equal to or greater than expected reward, things go fine. When attained reward is less than expected reward, frustration dissatisfaction result. For most people reward is equal to achieving promotion and advancement or in some other way being successful enough at work to meet life objectives.

How do we grow, advance, and achieve the expected reward (in terms of life objectives) that made us select a specific career in the first place? The person who selects a career in technology needs to consider the following criteria for success and advancement in the field:

1. Am I willing to be dedicated to the objectives of my employer?
2. Am I willing to perform tasks that other people are unwilling or unable to perform?
3. Do I get along positively with my fellow workers, managers, customers, and others?
4. Do I stay abreast of current developments in my technology?
5. Do I evaluate and update my technical knowledge and skill?
6. Will I assume responsibility without being asked?
7. Have I carefully set my personal objectives and worked to attain them?
8. Am I willing to accept only my best as being good enough for me?

If you can answer yes to all of the preceding questions, there is little doubt that you will progress and grow as an engineering technician and you will receive the rewards that your chosen career can offer to you.

Federal law prohibits discrimination on the basis of race, color or national origin (Title VI of the Civil Rights Act of 1964); sex (Title IX of the Educational Amendments of 1972 and Title II of the Vocational Education Amenaments of 1976); or handicap (Section 504 of the Rehabilitation Act of 1973) in educational programs or activities receiving federal financial assistance.

Employees, students and the general public are hereby notified that the Georgia Department of Education does not discriminate in any educational programs or activities or in employment policies.

The following individuals have been designated as the employees responsible for coordinating the department's effort to implement this nondiscriminatory policy.

Title II - Ann Lary, Vocational Equity Coordinator
Title VI - Peyton Williams Jr., Associate Superintendent of State Schools and Special Services
Title IX - Myra Tolbert, Coordinator
Section 504 - Jane Lee, Coordinator of Special Education

Inquiries concerning the application of Title II, Title VI, Title IX or Section 504 to the policies and practices of the department may be addressed to the persons listed above at the Georgia Department of Education, Twin Towers East, Atlanta 30334; to the Regional Office for Civil Rights, Atlanta 30323; or to the Director, Office for Civil Rights, Education Department, Washington, D.C. 20201.

Program Improvement and Evaluation
Office of Vocational Education
Georgia Department of Education
Atlanta, Georgia 30334
Charles McDaniel, State Superintendent of Schools
1985